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URNATELLA GRACILIS, A FRESH-WATER POLYZOAN.

By Prof. Joseph Leidy.

Upwards of thirty years ago, and on several subsequent occasions, in the Proceedings of this Academy (1851, 321; 1854, 191; 1858, 1; and 1870, 100), the writer has briefly described or noticed an interesting fresh-water ciliated polyp, or polyzoan, to which the name of Urnatella gracilis was given. It was first discovered in the Schuylkill River, under low-tide mark, below Fairmount dam, Philadelphia. It was found in association with *Plumatella*, *Paludicella*, and other animals common in such positions. At the times of collecting it in 1854 and in 1870, it was in comparative abundance in the locality, but lately appears to have become scarce, due to the destructive influence of the city sewage which now flows so abundantly into the river.* In similar places under favorable circumstances, *Urnatella* is probably not rare, though incidentally in the search of aquatic animals I have not found it elsewhere, nor have

* Last autumn, on going to the locality to collect *Urnatella*, I found the original spot rendered unfit for animal life, and therefore failed in my object. On another trip I collected a few specimens from which most of the drawings accompanying the present communication were made—a short distance below the former place, at the mouth of the neighboring canal. In the autumn of 1876, I joined a party to explore the Schuylkill River, below the city, by dredging, and I had the agreeable anticipation of obtaining abundance of *Urnatella*, together with other interesting animals. We were disappointed in our expectations, for we found the sediment of the river, everywhere from the city to the mouth of the Schuylkill, imbued with oil, derived from the waste of the gas-works and oil refineries, so that no living thing could exist.

I seen any published notice of its having been discovered by other observers. In one instance, my friend Dr. Isaac Lea directed my attention to the shell of a *Unio*, from the Scioto River, Ohio, on which were several dried, but still characteristic, specimens of *Urnatella*. This fact not only indicates the existence of the polyp in the valley of the Mississippi, but probably also a wide distribution of it throughout the country.

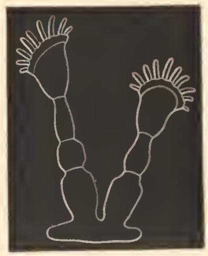
From the time I first saw *Urnatella* I felt it was of such interest as to be worthy of a thorough investigation, and this I resolved to undertake at a favorable opportunity. Other occupations, and the want of a ready supply of the necessary material, have prevented my intention, and I am now led to communicate what I have learned of the animal, with the view that some of my younger countrymen and co-laborers, under more favorable circumstances, may be induced to do what I had hoped and wished to do.

Urnatella is a most beautiful form, and quite peculiar among the known fresh-water polyzoa. In its relations it is most nearly allied to the marine genus *Pedicellina*, typical of a small order of the polyzoa, and of the family Pedicellinæ.

Urnatella lives in positions and has habits similar to those of the familiar *Plumatella*, species of which are found almost everywhere in fresh waters, from the little rivulet to the largest lake. It is attached to fixed objects, commonly the under side of stones, beneath which the water freely flows. In this manner it was repeatedly collected on stones, taken from the bed of the Schuylkill River, in association with *Plumatella vesicularis*, *Paludicella elongata*, *Limnias socialis*, *Hydra carnea*, *Spongilla fragilis*, and several worms, such as *Planaria*, *Emea rubra*, *Clepsine*, *Manayunkia speciosa*, etc. In the same locality, in a few instances, I found it attached to shells of *Unio complanatus* and *Melania virginica*; and less frequently young specimens were observed on eel-grass, *Vallisneria spiralis*, and on water-star-grass, *Schollera graminea*. Recently Mr. Edward Potts submitted to me several specimens taken from a piece of sunken wood from the canal at Fairmount.

As more commonly observed, *Urnatella* consists of a pair of stems pendant from a common disk of attachment and terminating each in a single polyp-head or bell, or in several little branches terminating in like manner, as seen in figures 1, 2, Plate I. The stems diverge, straight or in a gentle curve, are slightly tapering, beaded in appearance, alternately whitish or brownish white and black. Usually they are composed of from two to a dozen segments, including the terminal polyp-bell, and reach from an eighth to a sixth of an inch in length. The largest specimens observed consisted of eighteen segments, with a length of about the fourth of an inch. The beaded appearance of the polyp-stems is due to the expansion with light coloring of the median portion of the segments, and the intermediate narrowing and black color of the conjoined extremities of the segments. The stems may end alone in a single polyp-bell, but commonly in addition they have one or two pairs of lateral branches with terminal bells, coming off from the two segments of the main stem next to its terminal bell. Frequently also in like manner the primary branches give off secondary ones. See figures of Plate I, and also the accompanying woodcuts.

1. Young *Urnatella*, in which one stem consists of a simple pedicel with a polyp-bell, and the other stem is divided into two segments besides the polyp-bell.



2. Young *Urnatella*, in which one stem consists of two segments supporting the polyp-bell, and the other of three segments with the polyp-bell. The first segment of each stem has assumed the urn-like form.

Rarely, a branch, consisting of two or more segments, is given off, apparently with no regularity, from any other of the segments of the main stem than the usual ones, as represented in figure 4, Plate I.

Sometimes the polyp-stock of *Urnatella* consists of a single stem arising from its base, and at others it may consist of a number up to half a dozen, starting from the same disk of attachment.

The stems of *Urnatella* are highly flexible, but not contractile or capable of being visibly shortened or narrowed, except perhaps in the case of the one or two segments next the bell, which sometimes appear feebly contractile, especially in young specimens. In the usual condition the stems appear nearly straight, or slightly curved, but after intervals of quiescence they are observed spontaneously and rather abruptly to bend and twist, as if wearied from remaining so long in the same position. Not unfrequently the movement is quickly repeated before the polyps resume their temporary rest. Similar movements are to be seen in the comparatively long unsegmented pedicels of the marine *Pedicellina*. In *Urnatella* the movement extends throughout the entire length of the segmented stem, and is by no means confined to the terminal more flexible segments, as might be supposed from a view of the movements of *Pedicellina*. Like the latter, *Urnatella* is exceedingly sensitive; with the slightest disturbance the tentacles are quickly doubled on themselves and drawn within the mouth of the bell, which is then closed by contraction, and the stem is suddenly bowed outwardly, so that the head is brought to the ground, or when the stem is long, as in more mature specimens, it may become involute, as represented in figure 1, Plate I.

The segments of the stem of *Urnatella* are chiefly urn-like in shape and are nearly uniform in size and other respects, except the first one and the last two of the series next the bell. The body of the urns forms the swollen, translucent, light-colored portions of the segments, and exhibits a more or less finely and transversely wrinkled appearance, lined with brown in the same direction, and also spotted with brown, or often furnished with little tubercles of the same color. The neck and pedicels of the urns conjoin one another in the different segments, and are black and opaque. The first segment of the stem is likewise urn shaped, like those which usually succeed it, but is considerably larger, and its pedicel expands into a broad, circular or oval disk, which tightly adheres to the stone on which the polyp is attached. The two segments of the stem of *Urnatella*, next the bell, are narrower, more cylindroid, softer, more translucent and more flexible than the others, and they are not abruptly contracted and blackened at the extremities. The last segment, attached to the bell, is cylindrical or often clavate, and colorless. The preceding segment is barrel-shaped, or intermediate in shape to the former and the urns, and is colorless or slightly colored like the latter.

The polyp-stem of *Urnatella* is composed of an external homogeneous, tough, chitinous integument, transparent and colorless, or of a pale amber hue, except at the constricted portions of the stem, where it appears black. and elsewhere, where it appears lined and dotted with brown. It extends in a delicate layer upon the terminal segments of the stem to the outside of the polyp-bell. The disk of attachment of the polyp-stems is mainly composed of an extension of the chitinous integument.

Within the more translucent portions of the stems of *Urnatella*, a cylindrical cord is seen extended throughout the axis. from the base of attachment to the polyp-bell. It fills the narrower portions of the urn-like segments, and usually also the whole of the segment next the bell. In the wider portions of the stem a more translucent interval is occupied by indistinct and undetermined material. The axis cord of the stem is superficially finely striated in the length, and interiorly appears to be composed of a granulated substance, as represented in figure 2, Plate I, where a portion is seen extending from the end of the first segment of a stem.

Projecting usually from the opposite sides of the urn-like segments of the stem of *Urnatella*, as represented in most of the accompanying figures, there are commonly little cup-like processes of chitin, corresponding with the position in which branches are given off from the more terminal segments. These I originally looked upon as buds, but more attentive examination proving them to be empty shells of chitinous matter, I have been led to suspect that they are the remains of branches of the polyp, which have separated from the parent to be established in the foundation of colonies elsewhere. Sometimes a single cup-like process occurs only on one side of the urns, and rarely two pairs appear on opposite sides of the same segment. Occasionally specimens are found in which, instead of one of the cups, a branch is given off, as represented in figure 4.

In the simplest condition *Urnatella* is observed as a polyp-bell attached to a simple cylindrical pedicel, thus resembling the ordinary appearance of an individual *Pedicellina*. Such a specimen is represented in figure 5, occurring in the usual way as a pair of individuals springing from a common disk of attachment. The simple pedicel is much longer than the corresponding segment in the more divided stem of *Urnatella*, but is otherwise of the same character. It appears as a solid column, translucent white, and consists of an internal cord or axis, longitudinally striated and muscular in nature, invested with a transparent chitinous integument. The pedicel is highly flexible, spontaneously bends in all directions, but appears to be feebly if at all contractile.

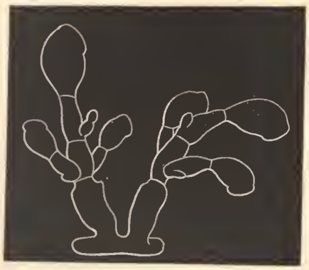
Other specimens of *Urnatella* were observed in which one or both pedicels, as in those just described, were more or less distinctly divided each into two segments, as represented in woodcut 1, and in figures 6, 7, of Plate I. These evidently indicate the origin of the segments of the stem of *Urnatella* through continued growth and the process of successive division of the originally simple pedicel. Abundance of specimens of *Urnatella* occur with segments ranging from the smallest to the greatest number, clearly indicating the successive production of the segments through the process of division, very much in the same manner as in the production of the proglottides of tape-worms from a *scolex*.

In the first view of *Urnatella* one might suppose that the segments of the stem represented so many distinct polyps as in *Plumatella*, but examination leads to the fact that the terminal polyp is the only one of the series.

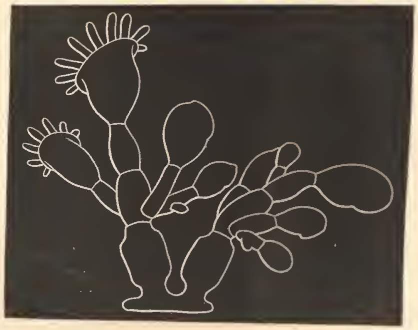
In the production and growth of the segmented stems of *Urnatella*, after the first division of the original simple pedicel, which is a cylindrical column, the segments distally from the latter and its polyp-bell, successively assume the characteristic urn-like shape observed in the more matured specimens, and as represented in figures 1, 2, 4, 8. In most matured specimens observed the stems rarely consisted of more than a dozen segments, including the polyp-bell.

After the division of the simple pedicel of the young *Urnatella* into two or more segments, the various specimens observed would appear to indicate that the one or two segments next the bell put forth buds in pairs laterally near the upper end or base of the segments. These buds appearing as spheroidal or ovoidal processes, then develop and grow into branches, commonly consisting of a bell and pedicel like the early parent. In like manner specimens go to show that secondary branches are produced in a similar manner from the primary ones. Woodcuts 3 and 4 represent examples of such specimens just described.

From the usual mode of branching of *Urnatella*, that is to say, from the branches coming off from the two segments of the stem next the polyp-bell, and from the usual absence of branches from the succeeding urns, with the presence of the apparent remains of branches as empty cup-like processes, I have been led to suspect that the branches are spontaneously and habitually detached from the parent stem, to become elsewhere attached, and thus form new colonies. The separation I have not actually observed, nor have I had an opportunity of ascertaining if such is the fact, since the suspicion occurred to me. The specimens which have come under observation, as illustrated by the accompanying drawings, exhibit every step of the process, so as to render the view at least probable. In further confirmation of it, I may add that in one instance in which I placed a number of profusely branching specimens of *Urnatella* in an aquarium, after a few days I noticed that they had been shorn of most of their branches, but whether this was the natural healthy course in the life of the animal, or due to unfavorable circumstances, I am not ready to decide.



3. Young *Urnatella*, in which the two segments next the polyp-bell give off buds and branches.



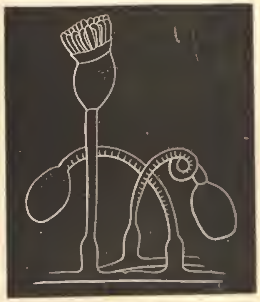
4. Young *Urnatella*, giving off both primary and secondary branches. Buds are also seen given from the latter.

The polyp-head, or polyp-bell, of *Urnatella* (see figure 3), which terminates the main stem and its branches, when in active condition, appears as a bell-shaped body, with a widely expanded oval or nearly circular mouth, directed obliquely to one side or ventrally. The mouth of the bell is bordered by a broad waving band or collar, from the inside of which springs a circle of tentacles. Of these there are usually sixteen, though sometimes I have counted fourteen and twelve. They are cylindrical and reflected from the mouth of the bell. They are invested with an epithelium, furnished with moderately long, active cilia. From their root longitudinal fibres, muscular in character, diverge on each side to the inner surface of the collar embracing them.

The outer surface of the polyp-bell is smooth, though occasionally I have seen specimens in which it appeared to be furnished with minute scattered tubercles.

The interior of the polyp-bell is mainly occupied by the alimentary apparatus. The mouth of the bell converges in a wide funnel-like manner to the pharynx, which occupies the ventral or shorter side of the bell. When the tentacles are retracted, they are doubled on themselves and withdrawn into the funnel-like mouth of the bell. and the collar marked with circular fibres contracts in a circular band around them. The mouth of the bell is lined with ciliated epithelium, and the cilia produce visible currents convergent to the bottom of the funnel or pharynx. From the latter a cylindrical tubular œsophagus is extended upwards along the shorter or ventral side of the body, and turns dorsally to open into the stomach. The walls of the pharynx

5. *Urnatella*, with stem of four segments with polyp-head giving off a branch, with a pair of secondary branches.



6. *Pedicellina*, from Newport harbor, R. I.

and œsophagus are formed of short columnar ciliated epithelium. The movements of the cilia are directed into the stomach. This is a capacious organ, which nearly occupies half the interior of the polyp-bell, and always appears more or less filled with liquid and solid materials, which are kept in incessant motion. The stomach in shape resembles a retort or still, with an alembic, and consists of a large oval thick-walled receptacle with a conical prolongation or pylorus extended from the former at its lower part downward on the dorsal or deeper side of the body. The upper part of the stomach is flattened, and is connected with the bottom of the polyp-bell by a sort of button, which appears to be a continuation of the interior muscular cord of the stem of the polyp. The lateral walls of the stomach are formed of thick columnar epithelium; the upper part and the sides of the pylorus of a much thinner layer. The epithelium of the ventral wall is colored brown, and probably partakes a hepatic function. Throughout, the stomach is furnished with long, active cilia, which keep the contents in incessant motion, whirling them from right to left towards you, and then in the reverse course, and maintaining the solid materials in the long axis of the cavity. The contents of the stomach, ordinarily seen, consist of an elliptical mass occupying the pyloric cavity, with a tapering twisted prolongation extending into the main cavity. With this solid food, diatomes, desmids, and other vegetable organisms, may often be detected.

With the exception of the few specimens of *Urnatella* which were collected the last autumn, those of former collections were remarkable for being almost invariably infested with a ciliated infusorian, living in the stomach. The infusorian, a species of *Anoplophrya*, which I have described under the name of *Leucophrys socialis*, was observed in variable numbers, sometimes few, at others in such a multitude as to fill the main receptacle of the stomach. They congregate together in the central portion of the latter, and together with the food are kept incessantly whirling around through the ciliary action of the stomach, while they, at the same time, move spontaneously among one another in a swarming manner.

From the lower end of the pylorus, a short, tubular intestine descends, and turns inwardly to expand in an elliptical pouch or colon. This occupies a position obliquely between the lower portion of the stomach, including the pylorus dorsally, and the funnel of the polyp-bell ascending from the mouth to the pharynx. Its upper extremity is extended as a short tubular rectum, which terminates just below the centre of the funnel converging to the pharynx.

The walls of the intestine, including the colon and rectum, are composed of short columnar epithelium, and exhibit no ciliary movements. The colon is usually occupied by an elliptical mass of excrement, which from time to time is suddenly expelled through the short rectum and the mouth of the polyp-bell.

The long, active cilia of the expanded tentacles of *Urnatella* give rise to a lively circular current in the surrounding water, which brings particles of food within the power of the polyp. The food, consisting mainly of vegetable matters, is conveyed by currents, induced by the ciliary lining of the throat of the polyp-bell, to the pharynx, and thence by continuous ciliary action is conducted through the œsophagus into the stomach. Here the accumulating food mass, whirled around and maintained in position in the long axis of the cavity, undergoes digestion. The thicker portion of the mass, occupying the pylorus, after a time is passed into the colon, where it remains a while in a quiescent state, and is finally discharged.

When the tentacles of *Urnatella* are doubled upon themselves, and retracted within the throat of the polyp-bell, the whirl of the mass of food in the stomach is retarded or prevented, though the ciliary action is still observable within the main cavity of the stomach and in the pharynx.

In none of the specimens of *Urnatella* which have come under my observation, have I been able to detect the slightest trace of organs of generation or ova. I have further been unable to discover distinct elements of a nervous system. At times I have thought I could obscurely distinguish the presence of a body in the interval between the pharynx, stomach and colon, that I suspected to be a ganglion, but obtained no definite view of it.

On the approach of winter, or under unfavorable circumstances, the polyp-bell of *Urnatella* dies and disappears. During the winter the matured segmented stems apparently continue alive and unchanged. It has occurred to me that the urn-like segments of the stem serve as reproductive bodies, of the nature of the statoblasts of *Plumatella*. Ordinarily they do not appear disposed to become isolated or separated from one another; at least I have never observed them in the latter condition. Perhaps, as reproductive bodies, after the polyp-bells perish, they remain in conjunction securely anchored through the first of the series, and are preserved during the cold of winter, until under the favorable condition of spring, they put forth buds and branches, which, by separation and settlement elsewhere, become the foundation of new colonies. In apparent confirmation of this view, I have repeatedly met with what appeared to be old stems and fragments of others, which had lost their polyp-bells and branches, and from some of the remaining segments had developed new polyp-bells. Such a specimen, collected late in September, 1882, is represented in figure 9. Further, I have observed specimens of *Urnatella*, preserved in an aquarium, after losing their polyp-bells in the autumn, remain in this condition all winter, and reproduce their polyp-bells the following spring.

Urnatella has the essential constitution of the marine polyzoan *Pedicellina*, and clearly forms a genus of the same family. The polyp-bells are alike in form and constitution. The arrangement of the tentacles and the course and construction of the alimentary canal, and the relative position of the oral and anal apertures, are the same.

In *Pedicellina*, a creeping root-stock or stem is attached to fixed bodies and gives off simple pedicels supporting each a polyp-bell. In *Urnatella* free segmented stems suspended from a fixed point end in a polyp-bell, and give off branches corresponding with the polyp-bell and pedicel of *Pedicellina*.

In another genus of the family, recently described by the Rev. T. Hincks under the name of *Barentsia*, the polyp-bells are like those of *Pedicellina*, but are supported on pedicels, which arise from an erect and undivided chitinous stem with a bulbous base.

The only known remaining genus of the family is *Loxosoma*, of which there are a number of species, remarkable generally from their living as parasites on marine worms. The species, too, are further remarkable from their occurring as isolated or single individuals, corresponding with the polyp-bell and pedicel of the other genera.

In this genus the polyp-bells put forth buds which develop into polyps like the parent; and the young polyps then spontaneously separate to attach themselves to other objects, just as we have reason to suppose is the case with the young of *Urnatella*.

The polyzoa of the family of Pedicellinæ, thus far described, are as follows:

PEDICELLINA.

1. PEDICELLINA CERNUA.

Smitt: Öfvers. Vetens. Akad. Förhand., Stockholm, 1871, 1132. Hincks: British Marine Polyzoa, 1850, 565.

Brachionus cernuus. Pallas: Naturges. merkw. Thiere, 1178, 57, Tab. IV, fig. 10.

Pedicellina echinata. Sars: Beskr. og Iagttag., 1835, 5, Tab. I, fig. 1. Hassall: An. Nat. Hist., 1841, 365. Johnston: British Zoophytes, 1847, 382, Pl. LXX, fig. 5. Nitsche: Zeits. wis. Zool., 1870, 13, Taf. 2, 3. Barrois: Rech. sur l'Embryol. d. Bryozoaires, 1877, 27, Pl. II.

Locality.—Shores of Norway, Spitzbergen, Heligoland, White Sea, Great Britain, France and Sicily.

2. PEDICELLINA GRACILIS.

Sars: Beskriv. og Iagttag., 1835, 6, Tab. I, fig. 2. Smitt: Öfvers. Vetens. Ak. Förh., Stockholm, 1850, 1133. Hincks: British Marine Polyzoa, 1850, 570, Pl. LXXXI, figs. 4–6.

Locality.—Norway, Spitzbergen, White Sea, Roscoff, Great Britain.

3. PEDICELLINA BELGICA.

P. J. Van Beneden: Mem. Acad. d. Sc. de Bruxelles, 1845, 23, Pl. I, II.

Locality.—Ostende, Belgium.

4. PEDICELLINA NUTANS.

Dalyell: Remarkable Animals of Scotland, ii, 1848, 63, Pl. XX. Hincks: British Marine Polyzoa, 1880, 567.

Locality.—Scotland; Tenby.

5. PEDICELLINA AUSTRALIS.

Ridley: Proc. Zool. Soc., 1881, 60, Pl. VI, fig. 8.

Pedicellina n. s.? Studer: Archiv f. Naturges., 1870, 124.

Probably not different from the succeeding species.

Locality.—Straits of Magellan; Kerguelen Land.

6. PEDICELLINA AMERICANA.

Leidy: Jour. Acad. Nat. Sc., 1855, 11, Pl. X, fig. 25. Verrill: Rep. of the Sea Fisheries, of 1871, 2, Washington, 1873, 405, 707. Ryder: Rep. of Com. of Fish. of Maryland, 1881, 34.

Locality.—Point Judith, Rhode Island; Chesapeake Bay, Md.

7. PEDICELLINA.

Among some notes I find the following description and accompanying sketch of a species of *Pedicellina* (woodcut 6), apparently different from the preceding. The specimen was obtained in Newport harbor, R. I., from a depth of twenty fathoms, in July, 1859. Polyp-stock, a creeping, jointed root, sending off stems supporting single polyp-bells, from one to three lines long. Stems or slender pedicels slightly tapering from the polyp-bell to near the base, which is abruptly enlarged; longitudinally striate and colorless. Polyp-bell campanulate, with upwards of a dozen tentacles. Alimentary canal as in other species; stomach with a brown liver-spot.

Polyps exceedingly sensitive, on the slightest disturbance closing their bell and bowing the highly flexible muscular stems, which often become more or less revolute. The species nearly resembles *P. gracilis*, and may be the same. It has no median dilatation to the stem, and this is long and slender, and even becomes revolute when the animal is disturbed, while in *P. gracilis* it appears simply to bend downward from the base.

BARENTSIA.

Barentsia bulbosa.

Hincks: An. Nat. Hist., 1880, 285, Pl. XV, figs. 12–14. Urban: Ibidem, 276.

Locality.—Barent's Sea.

URNATELLA.

Urnatella gracilis.

Leidy: Proc. Ac. Nat. Sc., 1851, 321; 1854, 191; 1858, 1; 1870, 100. Allman: Fresh-water Polyzoa, 1856, 117.

! Urnabella "d'eau douce de l'Australie." Salensky: An. Sc. Nat., 1877, 47.

Locality.—Schuylkill River, Philadelphia; Scioto River, Ohio.

LOXOSOMA.

Keferstein, 1863.

Strephenterus, 1861. Norman. Described by the author as an echinoderm, but as he subsequently (recognizing the true position of the animal on which the genus was founded), adopted the later name, with other authors, I have followed him.

1. Loxosoma singulare.

Keferstein: Zeits. wis. Zool., 1863, 131, Taf. XI, fig. 20. Claparede: Beob. u. Anat. u. Entw. wirb. Thiere Normandie, 1863, 105, Taf. II, figs. 6–10. Schmidt: Arch. mikr. Anat., 1876, 3. Barrois: Embryol. d. Bryoz., 1877, 9, 10, Pl. I, XVI, fig. 6. Hincks: British Marine Polyzoa, 1880, 573, Pl. 81, fig. 78. Norman: An. Nat. Hist., 1879, 137. Urban: Ibid., 1880, 276.

Locality.—St. Vaast-la-Hogue, Normandy; Shetland Islands; Barent's Sea.

2. Loxosoma neopolitanum.

Kowalewsky: Mem. Acad. Sciences, St. Petersbourg, 1866. Norman: An. Nat. Hist., 1879, 137.

Locality.—Bay of Naples.

3. Loxosoma kefersteinii.

Claparede: An. Sc. Nat., 1867, 28, Pl. VI, figs. 1–3; Zeits. f. wis. Zool., 1870, 34, Taf. XI, fig. 4. Nitsche: Ibid., 1875, 451; Supplem., 361, Taf. XXV, figs. 4–20, Taf. XXVI, figs. 7–13. Norman: An. Nat. Hist., 1879, 137.

Locality.—Bay of Naples.

4. Loxosoma claviger.

Strephenterus claviger. Norman: An. Nat. Hist., 1861, 112, Pl. IX, figs. 1–4.

Loxosoma phascolosomatum. Vogt: Arch. Zool. Exp., 1876, 305, Pl. XI, XII. Barrois: Embryol. Bryozoaires, 1877, 8, Pl. XVI, figs. 3, 4. Norman: An. Nat. Hist., 1879, 133, 137. Hincks: British Marine Polyzoa, 1880, 574.

Locality.—Roscoff; Bantry Bay, Ireland.

5. Loxosoma cochlear.

Schmidt: Arch. mikr. Anat., 1876, 3; Zeits. f. wis. Zool., 1878, 69. Norman: An. Nat. Hist., 1879, 137.

Barrois views it as the same with *L. neapolitanum.*

Locality.—Bay of Naples.

6. LOXOSOMA RAJA.
Schmidt: Arch. mikr. Anat., 1876, 3, Taf. I, fig. 1; Zeits. f. wis. Zool., 1878, 71. Norman: An. Nat. Hist., 1879, 137.

Locality.—Naples.

7. LOXOSOMA ALATA.
Barrois: Embryologie Bryozoaires, 1877, 9.
L. pes = *L. singulare.* Schmidt: Zeits. wis. Zool., 1878, 69, 70. Norman: An. Nat. Hist., 1879, 137.

Locality.—Naples.

8. LOXOSOMA CRASSICAUDA.
Salensky: An. Sc. Nat., 1877. Schmidt: Zeits. f. wis. Zool., 1878, 71. Norman: An. Nat. Hist., 1879, 137.

Locality.—Bay of Naples.

9. LOXOSOMA TETHYÆ.
Salensky: An. Sc. Nat., 1877. Schmidt: Zeits. f. wis. Zool., 1878, 71. Norman: An. Nat. Hist., 1879, 137.

Locality.—Bay of Naples.

10. LOXOSOMA CLAVIFORME.
Hincks: British Marine Polyzoa, 1880, 575, Pl. 81, figs. 9–12.

Locality.—Guernsey Island, English Channel.

PLATE I.

EXPLANATION OF THE FIGURES OF URNATELLA GRACILIS.

FIG. 1. Incurved appearance of the stem and closed condition of the polyp-bells, as the position assumed by *Urnatella* when disturbed. The main stem represented consists of eleven segments, including the polyp-bell. The other stem consisted of nine segments, including the polyp-bell. 75 diameters.

FIG. 2. Appearance of *Urnatella* fully extended. The main stem of a dozen segments, including the polyp-bell. The first segment of the second stem represented with the molecular structure of the central cord projecting. 75 diameters.

FIG. 3. Polyp-bell of *Urnatella*, with the succeeding segment. 166 diameters.

FIG. 4. Specimen in which a branch of six segments is given from the second segment of the main stem, consisting of eleven segments. The other main stem, of ten segments, likewise gave off a branch which consisted of five segments. 40 diameters.

FIG. 5. Young *Urnatella;* each stem consisting of a polyp-bell and simple pedicel. 75 diameters.

FIG. 6. Young *Urnatella;* in which one stem has a simple pedicel, and in the other it has undergone division into two segments. 75 diameters.

FIG. 7. Young *Urnatella*, in which both stems are divided into two segments. One stem extended with the polyp-bell expanded; the succeeding segment with a bud. The other stem bowed and the polyp-bell closed, the position assumed when the polyp is disturbed. 75 diameters.

FIG. 8. *Urnatella*, with the two stems each of five segments, including the polyp-bell. Polyp at rest, the stems bowed and bells closed. 55 diameters.

FIG. 9. Apparently an old polyp-stock of *Urnatella*, with a new lateral branch, consisting of a polyp-bell with its pedicel. From the latter a bud has put forth. 66 diameters.

THE TERRESTRIAL MOLLUSCA INHABITING THE SOCIETY ISLANDS.

By Andrew Garrett.

The Society Islands, which are the largest and most important group in southeastern Polynesia, comprise eight islands of volcanic origin and two of coral formation. Seven only, *i. e.*, Tahiti, Moorea, Huaheine, Raiatea, Tahaa, Borabora and Maupiti, have each one or more species peculiar to it or not found elsewhere.

Tahiti, the largest island in the group, is about thirty-eight miles long and twenty-three wide. It may be described as two islands of very unequal size connected by a low narrow isthmus. Moorea, which is eight miles west of Tahiti, is about nine miles long and six wide. Huaheine is seventy-two miles W. N. W. of Moorea and is about the same size as the latter island. Raiatea is twenty miles west of Huaheine and is about fourteen miles long and seven wide. Tahaa, which is about the same size as Huaheine, is two miles north of Raiatea and inclosed in the same encircling reef with the latter island. Borabora is about half the size of Huaheine and situated nine miles northwest of Tahaa. Maupiti, which is smaller than Borabora, is about twenty-three miles west of that island.

The earliest recorded Society Island land shells are *Limax faba* (= *Partula faba*), Martyn, and *Bulimus Otaheitanus* (= *Partula Otaheitana*), Bruguiere, which were published nearly a century ago. These two species were discovered when the islands were visited by Capt. Cook in his second or third voyage. From that early period up to 1819, when Ferussac recorded *Helix trochiformis* in his "Prodrome," no species, so far as I can learn, were published. In 1825, Dr. Gray added *Helicina Maugeria* to the list. In 1830, M. Lesson (Voy. Coquille) described *Auricula viola*, *Partula lutea*, *Helicina miniata* and *Partula lineata*, all Borabora shells, except the last, which inhabits Moorea, but was erroneously assigned to one of the Caroline Islands. In 1832, MM. Quoy and Gaimard (Voy. de l'Astrolabe) described an elongate dextral variety of *Partula Otaheitana* under the name of *Helix Vanicorensis*, and wrongly accredited it to Vanicoro in Melanesia.

The islands were next partially explored by that prince of collectors, Mr. H. Cuming, who discovered many new species which were described by Broderip, Reeve and Pfeiffer. But, unfortunately, he was so very careless in regard to the precise habitats of his shells that about two-thirds of the localities recorded on *his* authority are erroneous, and have, in consequence been a fruitful factor in the introduction of synonymous species. Several years after Cuming's visit, the naturalists of the United States Exploring Expedition, commanded by Capt. Wilkes, collected a number of new species, all of small size, which were described by Dr. Gould in the "Proceedings of the Boston Society of Natural History," and subsequently more elaborately described and figured in the official work, "Mollusca and Shells." In 1854, MM. Hombron and Jacquinot (Voy. Pol Sud), described two new species and added a synonym to Gould's *Helix Cressida*, two to Pfeiffer's *Helix coarctata*, and one to Gould's *Helix bursatella*. In 1867, Johann Zelebor, one of the naturalists of the "Novara" expedition round the world in 1857 to 1859, described *Pupa hyalina* (= *Vertigo pediculus*), *Pupa Dunkeri* (= *Vertigo tantilla*), and *Hydrocena Scherzeri*, all found on Tahiti; the last probably equals one of the extreme forms of the variable *Omphalotropis scitula*.

During the years 1860 to 1863, I made a much more thorough exploration than any of my predecessors, and, by searching in nearly every valley in the group, discovered over 50 new species. Most of these were described by the late Mr. W. H. Pease in the "Proceedings of the Zoological Society," and in the "American Journal of Conchology." The other species with his MS. names have been freely distributed, and the majority recorded in catalogues. All of these are for the first time described in the following pages. Since my residence in the group, from 1870 up to the present time, I have continued my researches, and added 19 new species to the list, one of which, *Partula acuticosta*, Mousson, MS., is recorded in "Museum Godeffroy Catal., v," and one, *Partula Mooreana*, Hartman, is described in the "Proceedings of the Academy of Natural Sciences of Philadelphia."

Genus MICROCYSTIS, Beck.

I restrict this genus to a group of small Helices, which are characterized by their orbicular, more or less depressed form, rounded, angulate or subangulate periphery, and smooth, shining surface. The umbilicus, though usually closed, is occasionally minutely perforated. The peristome is straight and sharp, with remote margins. The columella is simple, or callous, and frequently armed with a nodule or slightly twisted plait. In color they vary from whitish corneous, through all the intermediate tints, to fulvous; rarely ornamented with bands and spots. One species only exhibits a sculptured surface.

They are widely diffused throughout Polynesia, ranging from the lowlands near the seashore to several thousand feet above sea-level. A majority of the species are strictly terrestrial, and delight in moist stations, hiding beneath decaying leaves, under rotten wood and among loose stones. Others are entirely arboreal, on the foliage of shrubs and ferns. A number of the species are gregarious.

M. VERTICILLATA, Pease. Plate II, figs. 31, 31 *a*, 31 *b*.
Nanina verticillata, Pease, Amer. Jour. Conch., 1867, p. 228.
Helix verticillata, Pfeiffer, Mon. Hel., vii, p. 66.
Helicopsis verticillata, Pease, Proc. Zool. Soc., 1871, p. 475.
Nanina cicercula, var. "Mousson," Schmeltz, Cat. Mus. Godeff., v, p. 91.
Helix brunnea, Carpenter (Anton?), Proc. Zool. Soc., 1864, p. 675.

I found this species very abundant beneath moist rotten wood and amongst decaying leaves, on the north part of Moorea, and more rarely at Huaheine.

It is about the size and shape of *M. cicercula*, Gould, a Sandwich Island species, but differs in having a rounded periphery and more convex whorls. The Huaheine shells are a little larger and darker colored than Moorea specimens. The former have the inner edge of the columella simply thickened with callus, and in the latter the callus is frequently developed into a slight tubercle or somewhat twisted plait. My largest examples are 7 mill. in diameter.

M. SIMILLIMA, Pease. Plate II, figs. 32, 32 *a*, 32 *b*.
Helix simillima, Pease, Proc. Zool. Soc., 1864, p. 669. Pfeiffer, Mon. Hel., v, p. 56.
Helicopsis simillima, Pease, Proc. Zool. Soc., 1871, p. 475.
Nanina simillima, Schmeltz, Cat. Mus. Godeff., v, p. 207.

A somewhat rare species, peculiar to Raiatea, where it occurs high up in the mountain ravines, and is found beneath moist decaying leaves and under rotten wood.

Mr. Pease, who received his type specimens from me, correctly labeled as regards locality, gave the vague habitat "Central Pacific," and subsequently "Tahiti," where it does not occur. His brief diagnosis is not very satisfactory. I add the following description:—

Shell orbicular, depressed, thin, smooth, shining, pellucid, faintly striated, yellowish corneous; spire slightly elevated, convex, apex obtuse; suture faintly impressed, narrowly margined; whorls 3½–4, flatly convex, regularly and rather rapidly increasing, the last one not descending in front, depressed, periphery rounded; base flatly convex and deeply indented at the axis; aperture ovately lunate, nearly vertical; peristome thin, straight, regularly curved, with remote margins and simple columella.

Major diam. 10, height 4½ mill.

Its large size, depressed form, and rather rapidly increasing whorls, will readily distinguish it from any other South Polynesian species.

M. NORMALIS, Pease. Plate II, figs. 33, 33 *a*, 33 *b*.
Helix normalis, Pease, Proc. Zool. Soc., 1864, p. 669. Pfeiffer, Mon. Hel., v, p. 59.
Helicopsis normalis, Pease, Proc. Zool. Soc., 1871, p. 475.
Nanina normalis, Schmeltz, Cat. Mus. Godeff., v, p. 91.

Very abundant beneath rotten wood at Tahiti, Moorea and Huaheine. I add the following characters omitted by Mr. Pease in his short description:—

It varies in the height of the spire, the apex is obtuse, and the suture is margined by the fine periphery-keel. The beautiful oblique striæ are confined to the upper surface, the lower being smooth and more glossy. The axis is more or less distinctly punctate. The slightly oblique aperture is angulate-lunate.

The crowded, regular, raised striæ and delicate filiform keel will at once distinguish it.

M. Discordiæ, Garrett. Plate II, figs. 35, 35 *a*, 35 *b*.

Microcystis Discordiæ, Garrett, Jour. Phil. Acad. Nat. Sci., 1881, p. 383.

Nanina subtilis, Schmeltz (not of Anton), Cat. Mus. Godeff., v, p. 91.

Abundant under damp rotten wood, and ranges throughout the group. It is equally as common at the Cook's or Harvey Islands. A few specimens were taken by me at the Marquesas group.

A small, fragile species, about the size of *normalis*, with a more or less distinctly angulate body-whorl, smooth upper surface and lighter colored than the latter.

M. cultrata, Gould.

Helix cultrata, Gould, Proc. Bost. Soc. Nat. Hist., 1846, p. 172; Expl. Ex. Shells, p. 46, fig. 59. Pfeiffer, Mon. Hel., i, p. 37; (*Erepta*) Vers., p. 128.

Sagda cultrata (*Gastrodon*), H. and A. Adams, Gen. Moll., ii, p. 113.

Nanina cultrata, Gray, Cat. Pulm., p. 130. (*Microcystis*) Albers, Hel., p. 49. Bland & Binney, Amer. Jour. Conch., 1871, p. 189 (dentition).

Helicopsis cultrata, Pease, Proc. Zool. Soc., 1871, p. 475.

In 1862, I found examples of this species amongst decaying vegetation in Tahiti, but cannot state the precise locality.

It is a depressed, orbicular, very shining species, 6 mill. in diameter, with five whorls, the last one carinated and the columella dentated.

M. angustivoluta, Garrett. Plate II, figs. 34, 34 *a*, 34 *b*.

Shell small, orbicular, depressed, imperforate, thin, smooth, shining, pale amber-color, with or without small, irregular opaque-white spots; spire convex, apex depressed; suture faintly impressed, narrowly margined; whorls 5½–6, subplaniform, narrow, slowly and regularly increasing, last one depressed, not descending in front, periphery subangulate; base flatly convex, deeply indented at the axis; aperture nearly vertical, very narrow, luniform, much wider than deep; peristome thin, simple, with very remote margins; columella small, very oblique.

Major diam. 4½, lesser diam. 4, height 2½ mill.

Hab.—Moorea Island.

A few examples were found under damp rotten wood on the northeast part of the island.

Its most obvious characters are its depressed form, numerous, narrow whorls, subangulate periphery, narrow aperture and indented base.

M. SCALPTA, Garrett. Plate II, figs. 30, 30 *a*, 30 *b*.

Shell imperforate, orbicular, depressed, thin, smooth, subpellucid, very glossy; fulvous, minutely dotted and irregularly lineated with whitish radiating lines; spire convex, moderately elevated; suture rather faintly impressed; whorls five, flatly convex, moderately increasing, last one rounded, not deflected in front; base convex, indented at the axis; aperture nearly vertical, orbicular-lunate; peristome straight, thin, regularly curved, margins remote; columellar region thickened with callus.

Major diam. 10, height 6 mill.

Hab.—Tahaa Island.

This fine species occurs plentifully in a small area in Haamene valley on the east of Tahaa. They were gregarious beneath stones, rotten wood, and under heaps of decaying leaves. Not a single example taken in any other part of the island or group.

It is the same size as *simillima*, but may be distinguished by its more solid texture, darker color, more elevated spire, deeper body-whorl, more rounded aperture, and the whorls are flatter and more tightly coiled. The peculiar pale markings which suggested the specific name appear very much like scratches on the surface of the shell.

Genus TROCHONANINA, Mousson.

In 1869, Prof. Mousson established the genus or subgenus *Trochonanina* (Jour. de Conch., p. 329), for the reception of the Polynesian trochiform or conical Naninæ, the type of which is *N. Schmeltziana*. Mr. Pease injudiciously classed it with *Trochomorpha*, and *Helix conula*, Pse., which is precisely the same type he places in the genus *Helicopsis* = *Microcystis*.

I fully share Mousson's views in regard to the propriety of eliminating this group from the typical *Microcystis*. They differ from the latter genus in the more or less elevated-conical or trochiform shape, angulated or filocarinate periphery, closed or perforated base, and subrhomboidal luniform aperture. Like the preceding genus, the columella is either simple, nodulous or spirally plaited. The base is always smooth and shining; the superior surface is rougher, the striæ more decided and regular, sometimes rib-like, and frequently with fine spiral raised lines.

They possess the habits of *Microcystis*, and, except the Sandwich Islands, where they appear to be absent, have nearly the same distribution.

T. CONULA, Pease. Plate II, figs. 36, 36 *a*, 36 *b*.

Helix conula, Pease, Proc. Zool. Soc., 1861, p. 243. Pfeiffer, Mon. Hel., v, p. 62.

Helicopsis conula, Pease, Proc. Zool. Soc., 1871, p. 475.

Nanina Tongana, Schmeltz (not of Quoy and Gaimard), Cat. Mus. Godeff., v, p. 91 ("see Mousson").

Microcystis conula, Garrett, Jour. Acad. Nat. Sci. Phila., 1881, p. 383.

Rather plentiful on the foliage of low bushes and common to all the islands. It occurs, also, at Rarotonga, one of the Cook's or Harvey Islands.

Its trochiform shape, acutely angular body, and conspicuous peculiar columellar plait, will determine it.

T. OBCONICA, Pease. Plate II, figs. 37, 37 *a*, 37 *b*.

Helix obconica, Pease, Proc. Zool. Soc., 1864, p. 669. Pfeiffer, Mon. Hel., v, p. 85.
Trochomorpha obconica, Pease, Proc. Zool. Soc., 1871, p. 475.
Nanina obconica, Schmeltz, Cat. Mus. Godeff., v, p. 207.

This species is peculiar to Raiatea, where it is very local and somewhat rare. It occurs in the higher portions of two valleys, one on the east and the other on the west side of the island.

Its most essential characters are its depressed-trochoid form, acute carination, small but pervious umbilicus, and fine crowded striæ. My largest example is 8 mill. in diameter.

T. CALCULOSA, Gould.

Helix calculosa, Gould, Expl. Ex. Shells, p. 48, Pl. V, fig. 63. Pfeiffer, Mon. Hel., iii, p. 41.
Zonites (Conulus) calculosus, H. and A. Adams, Gen. Moll., ii, p. 116.
Nanina calculosa, Gray, Cat. Pulm., p. 126. Schmeltz, Cat. Mus. Godeff., v, p. 91.
Nanina (Trochomorpha) calculosa, Albers, Hel., p. 60.

Not uncommon on foliage and is diffused throughout the group, ranging from the lowlands near the seashore to about 1000 feet above sea-level. I also obtained many examples on Dominique, one of the Marquesas Islands, and a few at Malolo, one of the Viti group. Its existence in the latter location is the more remarkable as it has not been observed on any of the intermediate islands.

My largest examples, which are 4½ mill. in diam., and a trifle less in height, are larger than Gould's specimens. It may readily be distinguished by its globose-pyramidal form, angulate body-whorl and oblique aperture. The umbilicus, though generally closed, is sometimes punctiform, and the columella reflexed.

It is not included in Mr. Pease's List of Polynesian Land Shells.

T. SUBRUGOSA, Garrett. Plate II, figs. 38, 38 *a*, 38 *b*, 38 *c*, 38 *d*.

Shell small, imperforate, globose-conic, thin, subpellucid, fulvous; upper surface with crowded, slightly oblique, plicate striæ; spire depressed-conic, apex planulate; suture linearly impressed; base convex, smooth, glossy, indented at the axis; whorls 4–4½, strongly convex, slowly and regularly increasing, last one narrow, rounded, not descending in front, periphery with a thread-like keel; aperture slightly oblique, transversely ovate-luniform; peristome thin, simple, regularly curved, with remote margins; columella slightly thickened with callus.

Major diam. 2½, height 2 mill.

Hab.—Tahiti and Moorea.

This small sculptured species is somewhat rare. It was found under stones on the northwest side of Tahiti, at an elevation of about 1000 feet. A few examples were taken in a large valley on the north side of Moorea, but at a much less elevation above sea-level.

Its most important characters are its globose-conic form, rib-like striæ, dark color, smooth base and delicate periphery-keel. It cannot be confounded with any other Polynesian species.

T. Tahitensis, Garrett. Plate II, figs. 39, 39 *a*, 39 *b*, 39 *c*.

Shell small, subperforated, depressed-turbinate, thin, subpellucid, above with fine, sharp, crowded, oblique, elevated striæ, fulvous corneous; spire dome-shaped, smooth and rounded at the apex; suture moderately impressed, margined above by the continuation of the periphery-keel; base depressly convex, smooth, glossy, perforation punctiform, not deep; whorls four and a half, flatly convex, regularly increasing, last one narrow, not deflected in front, periphery with a prominent thread-like keel; aperture slightly oblique, ovate-lunate; peristome straight, acute, with distant margins; columella with a large, white, tubercular nodule.

Major diam. 2½, height 2 mill.

Hab.—Tahiti.

This, the smallest species inhabiting the group, was found adhering to the under side of loose stones at an altitude of 2000 feet, on the northwest side of Tahiti.

It is nearly the shape of *subrugosa*, but is more rare, smaller, whorls flatter, spire more regularly dome-shaped, striæ much finer, and the conspicuous columellar nodule will at once distinguish it.

Genus ZONITES, Montfort.

Z. Mooreana, Garrett. Plate II, figs. 28, 28 *a*, 28 *b*.

Shell small, perforated, orbicular, depressed, thin, pellucid, shining, faintly striated, whitish corneous; spire convexly elevated; suture faintly impressed, narrowly margined; whorls four, slightly convex, regularly and moderately increasing, last one somewhat depressed, not descending in front, rounded on the periphery; base depressly convex, deeply indented at the axis, which exhibits a small perforation; aperture subvertical, orbicular-luniform; peristome acute, straight, roundly curved, margins distant; columella simple.

Major diam. 4, height 2½ mill.

Of this small species I have five examples before me, all found associated with *M. verticillata* at Moorea.

It can scarcely be distinguished from *Z. Vitiensis*, except in being smaller, more polished, paler and the striæ smoother.

Genus TROCHOMORPHA, Albers.

So far as I can ascertain, the Society Islands are the only group in Eastern Polynesia inhabited by the above genus. Dr. Pfeiffer, on the authority of Anton, cites Opara = Rapa as one of the localities of *T. trochiformis*. If the genus occurs on that small island, which I very much doubt, the species is distinct from the Society Island shells. Mr. Gloyne, in his very valuable paper on the "Geographical Distribution of Terrestrial Mollusca" (Quar. Jour. Conch., i, p. 315), erroneously assigns three species of *Trochomorpha* to the Cook's Islands, where the genus does not occur. He is also wrong in referring the genera *Palaina, Cyclomorpha* and *Cyclophorus* to that group.

In the Society Islands all the Trochomorphæ are peculiar to the group, and occur on all the islands except Borabora and Maupiti. Having personally collected several thousand specimens at the five islands inhabited by the genus, and after a thorough study and critical comparison with numerous species from the various islands in the Western Pacific, I do not hesitate to assign five species to the group. One restricted to Tahiti, one to Huaheine, two common to Raiatea and Tahaa, and one common to Tahiti and Moorea.

T. TROCHIFORMIS, Ferussac.

Helix trochiformis (*Hellicella*), Ferussac, Prod., p. 301. Pfeiffer, Symb., ii, p. 40; Mon. Hel., i, p. 206. Chemnitz, ed. 2d, No. 68, p. 13, figs. 7, 8. Gould, Expl. Ex. Shells, p. 61 (part). Reeve, Conch. Icon., No. 606, Pl. CVIII, fig. 606.

Trochomorpha trochiformis, Albers, Die Hel., p. 116. Pfeiffer, Vers., p. 133. Pease, Jour. de Conch., 1871, p. 398; Proc. Zool. Soc., 1871, pp. 456, 474.

Zonites trochiformis (*Trochomorpha*), H. and A. Adams, Gen. Moll., ii, p. 115.

Nanina trochiformis (*Trochomorpha*), Albers, Die Hel., ed. 2d, p. 60. (*Discus*) Paetel, Cat. Conch., p. 85.

This very variable species lives on the trunks of trees and is restricted to Raiatea and Tahaa. Dr. Pfeiffer, on the authority of Anton, erroneously cites Tahiti and Opara = Rapa as its habitat. It is scarcely necessary to add that Ferussac's locality, "Isle de France," is also erroneous.

It is subject to more variation than any other known species. The usual proportion of height to the greatest diameter is 10 by 16, and the extreme variation 12 by 14 and 9 by 14 mill. The umbilicus is deep and narrow. Whorls six, convex, conspicuously margined, last one with a compressed periphery-keel. Base rather strongly convex, and Pfeiffer's "margine columellari recte descendente" is a well-marked feature in separating it from the nearest allied species. The color is yellowish brown, honey-yellow, more rarely orange-yellow, with a dorsal and basal deep brown-black, generally sharply defined band. The dorsal band which occupies the lower half of the whorls is narrower than the basal one, which latter is submarginal. The acute periphery-keel is pale straw-yellow. Occasionally the bands are diffused over the whole width of the whorls, except the keel and sutural margination. A more rare variety occurs of a pale greenish yellow, with the bands nearly or quite obsolete. Uniform honey-yellow specimens are also very rare.

Hybrids between this species and *Swainsonii* are not infrequent, and are more depressed, the umbilicus more open and the columella more obliquely curved than in the normal condition. Mr. Pease may have mistaken these hybrids for Gould's *Cressida*.

T. PALLENS, Pease. Plate III, fig. 43.

Helix trochiformis, Gould (not of Fer.), Expl. Ex. Shells, p. 61 (part).

Helix Cressida, Schmeltz (not of Gould), Cat. Mus. Godeff., v, p. 95.

Trochomorpha trochiformis, var. *pallens*, Pease, Jour. de Conch., 1870, p. 399; Proc. Zool. Soc., 1871, pp. 457, 474.

Common, but very local on the trunks of trees at Tahiti and Moorea. It has usually been confounded with *trochiformis*, and was described by Mr. Pease as var. *pallens*. After a critical comparison of a large number of specimens from the above-mentioned localities with the Raiatea shells, I have separated it as a distinct, though closely allied, species.

Shell umbilicated, rather solid, subtrochiform, obliquely and roughly striated, scarcely shining, yellowish white, with two narrow, revolving, reddish chestnut bands, the basal one the larger, and both submedian; spire depressly conoid, with nearly planulate outlines and rounded apex; suture with a narrow, depressed margin; whorls six, slightly convex, slowly and regularly increasing, last one not deflected in front, acutely and compressly keeled, keel whitish; base flatly convex, umbilicus narrow, about one-sixth the major diameter of the shell; aperture rhomboid-luniform; peristome, above the keel, acute, straight, beneath the keel, gently arched, receding; incrassated at the base.

Major diam. 16, height 9 mill.

Hab.—Tahiti and Moorea.

Var. *a.* Bands median, wide, blackish chestnut. Common.

Var. *b.* Pale honey-yellow, with narrow reddish brown bands, which are frequently marginal. Somewhat rare and local.

Var. *c.* Uniform whitish or yellowish white. Very rare.

Var. *d.* Excepting the white keel and sutural margin, blackish chestnut. Rather rare.

As compared with the preceding species, it is more depressed, the whorls flatter, the base more planulate, the striæ rougher and the columella more oblique and arched. The keel and sutural margin are white, and the aperture is more depressed.

Examples of these shells sent to three good conchologists were by one referred to *Cressida*, Gld., by another to *Apia*, H. and J., and the third referred it to *exclusa*, Fer. I sent at the same time specimens of *trochiformis*, which were correctly determined.

T. CRESSIDA, Gould.

Helix Cressida, Gould, Proc. Bost. Soc. Nat. Hist., 1846, p. 176; Expl. Ex. Shells, p. 57, fig. 56. Pfeiffer, Mon. Hel., i, p. 123.

Zonites Cressida, H. and A. Adams, Gen. Moll., ii, p. 114.

Nanina Cressida (*Discus*), Albers, Die Hel., ed. 2d, p. 62.

Helix Vahine, Hombron and Jacquinot, Voy. Pol. Sud, Pl. VII, figs. 1–4.

Helix exclusa, var., Pfeiffer (not of Fer.), Mon. Hel., iv, p. 115.

Helix Swainsoni, var., Pfeiffer, Mon. Hel., iii, p. 157.

Much doubt and confusion exist in regard to Gould's *Helix Cressida*, which he says inhabits Tahiti and Samoa; the latter location is undoubtedly wrong. Mr. Pease says (Jour. de Conch., 1870, p. 399) *Cressida* is a good species, and inhabits Raiatea. Having personally collected all Mr. Pease's Raiatea shells, and having now before me numerous duplicates, I have failed to discover one which coincides with Gould's description. Mr. Pease's *Helix lenta*, MS. (= *Swainsoni*, var.), is the nearest allied form, but is much smaller, thinner and has a more convex base.

Dr. Gould's original description is as follows:—

"T. variabilis, solida, depressa, lenticularis, acute carinata, nitida, dense et acute striata, coloribus flavo-viridibus et castaneis coalescentibus fasciata, infra subplanulata, umbilico magno et profundo perforata; anfr. 5 vix convexi; apertura triangularis; labrum acutum; faux lilacina.—Lat. $\frac{7}{10}$, alt. $\frac{1}{4}$ poll." (Gould).

The only shell I can satisfactorily refer to the above diagnosis is a somewhat scarce species inhabiting two large valleys on the northwest side of Tahiti. The localities are near the two principal harbors and probably were the first ones explored by the naturalists of Wilkes' Expedition.

I have now before me five examples, the largest measuring 18 mill. in the major diameter and 6 in height. It is a solid, shining, depressed shell, with crowded, irregular, rather sharp, obliquely curved striæ, and 5–5½ subplanulate whorls. The suture is margined by the continuation of the acute periphery-keel. The flatly convex base exhibits a wide umbilicus in which may be easily enumerated all the volutions. The color is light yellowish brown, with or without a dorsal and basal light chestnut band which gradually fades into the ground color. Occasionally the basal band is obsolete, and the dorsal one so faint as not to be seen except in certain lights. The aperture is diagonal, depressed, securiform, with three angles which suggested Gould's "apertura triangularis." The peristome, above the carination, is trenchant, rectilinear and regularly curved from the keel to the columellar region, the inner margin strengthened with callus.

T. Swainsoni, Pfeiffer.

Helix Swainsoni, Pfeiffer, Proc. Zool. Soc., 1846, p. 28; Mon. Hel., i, p. 122; (*Videna*) Vers., p. 132. Reeve, Conch. Icon., fig. 607. Carpenter, Proc. Zool. Soc., 1864, p. 675. Schmeltz, Cat. Mus. Godeff., v, p. 95.

Zonites Swainsoni (*Rotula*), H. and A. Adams, Gen. Moll., ii, p. 116.

Helix scuta, Pease, MS. Coll. Pease, 1863.

Helix lenta, Pease, MS. Coll. Pease, 1863.

Nanina Swainsoni (*Rotula*), Paetel, Cat. Conch., p. 85.

Trochomorpha Swainsoni, Pease, Proc. Zool. Soc., 1871, p. 474 (part).

This species, which inhabits Raiatea and Tahaa, occurs in nearly all the large valleys, but is not nearly so plentiful as *trochiformis*. It is a ground species, and may be found lurking under rotten logs, among decaying leaves, and, during rainy weather, may be seen creeping a short distance up the trunks of trees.

Dr. Pfeiffer, on the authority of Mr. Tucker, cites "Tahiti" as its habitat. I am confident it does not occur on that island.

It is a thin, depressed, acutely carinated species, of a luteous or whitish horn-color, with a dorsal and basal brownish red line; the upper one traversing the middle of the volutions, and the lower one submarginal. The whorls are depressed or slightly convex and striated by rather rough lines of growth. The faint sutural line is narrowly margined. The convex base is considerably excavated on the boundaries of the umbilicus, which latter varies from moderate to large, conical and freely exposing all the volutions. The very oblique aperture is depressed, subsecuriform. Peristome thin and nearly straight, above the keel, beneath which it gently recedes, and presents a slight curve to the axis of the shell. They vary some in the elevation of the spire, and occasionally the lineations are obsolete. My largest examples are 16 mill. in the greatest diameter.

The animal, as seen through the thin shell, is maculated with dark slate and light gray. The exposed parts are slender and of a light gray or slate-color with a grayish buff creeping-disk. The eye-peduncles are long and slender, darker generally than the other parts. The tentacles are very small, and the foot, which equals in length the major diameter of the shell, is laterally grooved.

Pease's *Helix lenta*, which gradually merges into the typical *Swainsonii*, is brownish horn-color, with or without a submedian obscure chestnut band, and usually has the whorls more convex and the last one narrower than in the type. It is closely allied to *T. abrochroa*, Crosse, inhabiting the Viti Isles.

T. ASSIMILIS, Garrett. Plate III, fig. 44.

Shell umbilicated, rather solid, subpellucid, subtrochiform, striæ fine and oblique; greenish horn-color, with two brownish red revolving narrow bands, one above nearly median, the other on the base and intermarginal; spire variable, more or less depressly conoid, rounded above; suture with a narrow pale margin; whorls $5\frac{1}{2}$–6, the upper ones convex, the three lower subplanulate, narrow, slowly and regularly increasing, the last one acutely carinated, the carina compressed, rugose; base subplanulate, umbilicus moderate, profound, with rounded margins; aperture diagonal, depressed, securiform; peristome thin, straight, above rectilinear, beneath the keel gently arched; columella and base incrassated.

Major diam. 15, height 7 mill.

Hab.—Huaheine.

This species is restricted to the above island, where it is not infrequent on the trunks of trees.

It has hitherto been confounded with *trochiformis* and *Eurydice*, the latter a Tonga species. It is more nearly related to *pallens* than any other species; but appears to me sufficiently distinct to rank as a separate species. They are very uniform in color and fasciation; they vary some in the elevation of the spire. The various species of this genus are so closely allied that it is difficult to express in words the specific differences.

Compared with *pallens* it is smaller, color different, the band *always* narrow, and the umbilical region more excavated. The whorls are also a little more flattened. The obliquely arched columella will at once separate it from *trochiformis*.

Genus PATULA, Held.

P. MODICELLA, Ferussac.

Helix modicella, Fer., Mus. Deshayes, in Ferussac's Hist. Moll., i, p. 90, Pl. LXXXVI, fig. 3. Pfeiffer, Mon. Hel., iii, p. 92; vii, p. 149. (*Patula*) Paetel, Cat. Conch., p. 92.
Nanina modicella, Gray, Cat. Pulm., p. 129.
Pitys modicella, Pease, Proc. Zool. Soc., 1871, p. 474.
Patula modicella, Schmeltz, Cat. Mus. Godeff., v, p. 93. Mousson, Jour. de Conch., 1873, p. 104.
Pithys Atiensis, Pease, Jour. de Conch., 1870, p. 394.
Pitys Atiensis, Pease, Proc. Zool. Soc., 1871, pp. 453, 474.
Patula Atiensis, Garrett, Jour. Acad. Nat. Sci. Phila., 1881, p. 386.
Helix Atiensis, Pfeiffer, Mon. Hel., vii, p. 165.
Patula vicaria, Mousson, Jour. de Conch., 1871, p. 11, Pl. III, fig. 2; 1873, p. 104. Schmeltz, Cat. Mus. Godeff., v, p. 93.
Helix vicaria, Pfeiffer, Mon. Hel., vii, p. 187. (*Patula*) Paetel, Cat. Conch., p. 93.

This species, which is distributed throughout the group, is found adhering to the under side of dead wood in the lowland forests. It appears to be more rare in the Paumotus, and is widely diffused over the Harvey Islands. I also obtained it in the Tonga, and Dr. Graffe gathered examples in the low coral islands of the Ellice group, which gives it a wider range than any other Polynesian species.

Dr. Pfeiffer, who was unacquainted with this species, copies Deshayes' description, and, on the authority of Mr. Cuming, cites Tahiti as its habitat. He describes it as follows:—

"T. minima, orbiculato-depressa, tenuissima striata, late umbilicata, corneo-fulva; anfr. 4½ convexusculi, sutura canaliculata separati; apertura simplex, rotundato-semilunaris. Diam. 3, alt. 1½ mill." (Pfeiffer).

The above brief diagnosis accords closely with the numerous examples before me. Though occasionally uniform fulvous horn-color, and sometimes pale corneous, they are nevertheless frequently ornamented with faint reddish brown stripes and tessellations. The four and a half whorls are separated by a channeled sutural line. The spire is slightly convex or planulate. Whorls convex, last one moderately flattened above the periphery, and the striæ consist of fine, very crowded, sharp, lamelliform riblets, which are very slightly biarcuate. The perspective umbilicus is nearly a third of the major diameter of the shell.

Mr. Pease's *Pithys Atiensis*, which I add to the synonymy, is thus described:—

"T. orbicularis, tenuiscula, late umbilicata, confertim costulata, flavido et rufo tessellato-strigata; spira vix elevata, apice obtuso; anfr. 5, convexi, ultimus ad peripheriam rotundatus; sutura bene impressa; apertura obliqua, subcircularis, lamellis carens; perist. simplex, rectum. Diam. 3, alt. $1\frac{3}{4}$ mill." (Pease).

The Harvey Island shells, which attain a larger size than those found elsewhere, differ none in shape and sculpture, and the coloration is the same as Society Island specimens. The umbilicus varies from one-fourth to one-third the greater diameter of the shell.

I also add to the synonymy Mousson's *Patula vicaria*, described as follows:—

"T. parvula, aperte umbilicata, orbiculato-depressa, regulariter et tenuiter costulato-striata, striis squamulosis, faciis pallide corneis et fuscis radiatim picta. Spira planiuscula, subarcte spirata; summo minuto, lævigato, obtuso; sutura perimpressa. Anfr. $4\frac{1}{2}$, lente accrescentes, convexi; ultimus lente descendens, supra paulo tumidulus, deinde regulariter rotundatus. Apertura subverticalis (15° cum axi), exacte lunato-semicircularis, plicis destituta. Perist. rectum, acutum; marginibus convergentibus; dextro et basali antrorsum leniter biarcuatis, columellari non reflexo, nec protracto. Umbilicus $\frac{1}{4}$ diametri æquans. Alt. 1·5, diam. 3 mill. Rat. anfr. 7 : 2. Rat. apert. 1 : 1" (Mousson).

With the exception of being a trifle smaller, is not dissimilar in any respect from the Harvey Island shells.

The above author has described a variety of *modicella* from the Kermandec or Sunday Island, as follows:—

"Anfractibus magis rotundatis, costulis, sed tenuibus; albescens, maculis et flammulis rufis transverse picta; diam. 3, alt. 1·2 mill." (Mousson).

P. CONSIMILIS, Pease. Plate II, figs. 12, 12 *a*, 12 *b*.

Helix consimilis, Pease, Amer. Jour. Conch., 1867, p. 227. Pfeiffer, Mon. Hel., vii, p. 262.
Helix radiella, Carpenter (not of Pfeiffer), Proc. Zool. Soc., 1864, p. 675.
Pitys consimilis, Pease, Proc. Zool. Soc., 1871, p. 474.
Patula societatus, "Mousson," Schmeltz, Cat. Mus. Godeff., iv, p. 73. Paetel, Cat. Conch., p. 95. Pfeiffer, Mon. Hel., vii, p. 482.
Patula consimilis, Schmeltz, Cat. Mus. Godeff., v, p. 207.

Common and diffused throughout all the larger valleys of Raiatea, where it is peculiar. Mr. Pease's habitat, "Tahiti," is wrong. I collected all his type examples at the former island.

The spire is convex, the first and second whorls planulate and the suture channeled. The whorls are narrow, slowly and regularly increasing, turgid next to the suture and the rib-like striæ are very thin and closely set. The aperture is nearly vertical and the parietal region with one or two laminæ.

P. ACUTICOSTA, Mousson, MS. Plate II, figs. 13, 13 *a*, 13 *b*.

Patula acuticosta, "Mousson," Schmeltz, Cat. Mus. Godeff., v, p. 93.
Helix acuticosta, Pfeiffer, Mon. Hel., vii, p. 480. (Name only.)

Though less abundant, is, like *consimilis*, confined to Raiatea.

So far as I can ascertain, there has been no description published. I subjoin the following:—

Shell widely umbilicated, depressed-orbicular, corneous with reddish brown tessellations; radiately striated with thin, rather closely set, slightly arcuate, riblets; spire flatly convex, apex planulate; suture deeply impressed; whorls five, convex, slowly and regularly increasing, turgid next to the suture, last one slightly depressed above, not descending in front, base convex; umbilicus large, perspective, exhibiting all the whorls, about one-third the major diameter of the shell; aperture nearly vertical, irregularly orbicular-lunate; parietal region with one or two, very rarely three laminæ; peristome simple, straight, with remote margins.

Major diam. $4\frac{1}{3}$, height 2 mill.

A very rare variety occurs which is uniform whitish horn-color.

As compared with *consimilis* it is larger, more depressed, umbilicus larger and ribs finer.

P. LAMELLICOSTA, Garrett. Plate II, figs. 11, 11 *a*, 11 *b*.

Shell small, widely umbilicated, orbicular, depressed, thin, subpellucid, brown or fulvous-brown, unicolored or tessellated with deeper brown; radiately striated with rather distant, oblique, slightly waved lamelliform riblets; spire flat, not rising above the penultimate whorl; suture deeply impressed; whorls four, convex, slowly and regularly increasing, the last not descending in front, rounded on the periphery, obliquely depressed above; umbilicus more than a third the greater diameter of the shell; aperture oblique, orbicular-lunate.

Major diam. 3, height $1\frac{1}{2}$ mill.

Appears to be a scarce species, living beneath rotten wood in damp stations at Tahiti. It is more openly umbilicated than any other Society Island species. The proportion of the umbilicus to the major diameter of the shell is the same as *P. gradata*, Gld., and the sculpture is similar to *P. tenuicostata*, Garr.

Genus PITYS, Beck.

As stated in my paper on the "Terrestrial Mollusca inhabiting the Cook's or Harvey Islands," published in the Journal of the Academy of Natural Sciences of Philadelphia, I restrict this genus to those species characterized by the existence of laminæ on both the parietal region and palate.

P. Maupiensis, Garrett.

Pitys Maupiensis, Garrett, Proc. Cal. Acad. Sciences, 1872, p. 204; Proc. Acad. Nat. Sci. Phil., 1873, p. 233, Pl. III, fig. 64.

Patula Maupitiensis, Schmeltz, Cat. Mus. Godeff., v, p. 93.

Helix Maupitiensis, Pfeiffer, Mon. Hel., vii, p. 481.

Very common, and confined to the small island of Maupiti.

It may be distinguished from any other Polynesian species by its fine, crowded, elevated (not costulate) striæ, convex spire, numerous very narrow rounded whorls, numerous internal laminæ and deep vertical umbilicus. The parietal laminæ are three, rarely two, and sometimes the one on the columellar region is obsolete. Besides the usual four palatal laminæ, there exist, sometimes, finer and shorter intermediate ones.

P. parvidens, Pease. Plate II, figs. 14, 14 *a*, 14 *b*, 14 *c*.

Helix parvidens, Pease, Proc. Zool. Soc., 1861, p. 243. Pfeiffer, Mon. Hel., v, p. 220.

Pitys parvidens, Pease, Proc. Zool. Soc., 1871, p. 474.

Patula incerta, "Mousson," Schmeltz, Cat. Mus. Godeff., v, p. 93.

Helix incerta, Pfeiffer, Mon. Hel., vii, p. 481.

Very abundant and confined to Tahiti, Moorea and Huaheine. Examples from the three different localities are precisely alike as regards the character of the fine, rib-like striæ, size of the umbilicus and shape of the spire. There are generally two, rarely three, parietal laminæ, and usually four, sometimes five in the palate. Tahiti and Moorea specimens are a little larger and darker-colored than those from Huaheine, which latter have a cinereous base.

P. consobrina, Garrett. Plate II, figs. 17, 17 *a*, 17 *b*, 17 *c*.

Shell umbilicated, thin, orbicular, depressed, radiately striated with very fine, crowded, nearly straight, membraneous riblets; yellowish horn-color, tessellated and striped with reddish brown; spire planulate; suture channeled; whorls six, very narrow, convexly rounded, subangulate next to the suture, slowly and regularly increasing, the last one not deflected in front, much deeper than wide, obtusely rounded on the periphery; base convex; umbilicus perspective, showing all the whorls, nearly a third the greater diameter of the shell; aperture vertical, narrow, irregularly orbicular-lunate; parietal region with four (very rarely three), and the palate with from seven to nine laminæ; peristome thin, straight, simple with remote margins; columella with or without a lamelliform plait.

Major diam. 3, height $1\frac{1}{2}$ mill.

Hab.—Huaheine Island.

Rare and peculiar to one valley. The spire is more planulate and the body-whorl deeper than *parvidens*. It also has one more whorl, and the laminæ are much more numerous than in the latter species.

P. subtilis, Garrett. Plate II, figs. 15, 15 *a*, 15 *b*, 15 *c*.

Shell umbilicated, orbicular, depressed, thin, yellowish corneous, tessellated and zigzagged with chestnut-brown; sculpture consisting of radiating, very thin, not crowded, subbiarcuate riblets; spire slightly convex, apex flat, suture channeled; whorls five, narrow, rounded, subangulate near the suture, slowly and regularly increasing, last one rounded on the periphery; base convex; umbilicus moderate, about one-fourth the major diameter of the shell; aperture vertical, narrow, orbicular-lunate; parietal wall with two, and the palate with four (rarely three or five) laminæ; peristome thin, straight, with remote margins.

Major diam. 3, height $1\frac{1}{2}$ mill.

Hab.—Huaheine Island.

A somewhat rare species, confined to a valley on the north end of Huaheine. It differs from *parvidens* in having the riblets much further apart, deeper channeled suture and the whorls angulated next to the suture.

P. PUNCTIPERFORATA, Garrett. Plate II, figs. 16, 16 *a*, 16 *b*, 16 *c*.

Shell small, perforated, orbicular, depressed, thin, corneous, tessellated above with reddish brown, beneath corn-color, or radiately striped with the same hue; striæ very closely set, thin, rib-like, subarcuated, smaller and more crowded beneath; spire convex or convexly rounded; apex planulate; suture deeply impressed; whorls six, rounded, narrow, regularly and slowly increasing, last one not descending in front, gibbous above; base convex; umbilicus very small, punctiform; aperture vertical, narrow luniform; parietal region with two (rarely three), and the palate with from four to five laminæ, one of which is columellar; besides the laminæ there exist parallel raised lines both on the wall of the aperture and in the palate; peristome thin, simple, with remote margins; columella thickened with callus.

Major diam. 3, height $1\frac{1}{4}$ mill.

Hab.—Moorea Island.

A few examples were found at the above locality, but not obtained in any other part of the group. The minute umbilicus will at once distinguish it from any other Society Island species. One specimen is uniform pale horn-color.

P. BORABORENSIS, Garrett. Plate II, figs. 18, 18 *a*, 18 *b*.

Shell orbicular, depressed, widely umbilicated, thin, corneous under a light brownish epidermis; above tessellated, beneath with or without undulating stripes of a dark chestnut-brown; sculpture consisting of small, thin, crowded slightly waved riblets; spire but little elevated, apex flat; suture deeply impressed; whorls seven, convex, very slowly increasing, last one subangulate, base convexly rounded; umbilicus large, perspective, exhibiting all the whorls; aperture subvertical, ovate-luniform; parietal region with four and the palate with five or six laminæ, peristome simple with remote margins.

Major diam. 5, height $2\frac{1}{4}$ mill.

Hab.—Borabora Island.

This, the largest species inhabiting the group, is comparatively rare, and is peculiar to the above island, where it was found about 900 feet above sea-level.

Its most obvious characters are its large size, wide perspective umbilicus, depressed form, numerous whorls, subangulate periphery and numerous laminæ.

Genus LIBERA, Garrett.

There exists a good deal of confusion in regard to the synonymy of the Society Island species of *Libera*, caused, no doubt, by the intermixture of specimens collected in different localities. Such, I am sure, was the case with the examples collected by the naturalists of the United States Exploring Expedition, which were described by Dr. Gould under the name of *Helix bursatella* and varieties. The numerous specimens collected by the writer at Tahiti and Moorea, in 1861, passed into Mr. Pease's possession, and, like Gould (with one exception), he regarded them as a single variable species.

In my subsequent explorations of the above two islands I made a careful study of the specimens gathered in the different valleys on each island, and am thoroughly convinced that there are several valid species included in Gould's *H. bursatella* and varieties. In fact the various species are as well defined and distinct from each other as the majority of Helices, and, so far as I know, do not intergrade with each other. It is particularly noteworthy that each species has its special habitat; some restricted to a single valley, and others ranging throughout two or more valleys, but never intruding on each other's localities. The Tahiti species are specifically distinct from the Moorea shells, and both differ from those inhabiting the Cook's group. It is a noteworthy and remarkable fact that this genus, which in this group is restricted to Tahiti and Moorea, is represented in all the leeward islands by the allied genus *Endodonta*.

Dr. Pfeiffer appears to have been somewhat bewildered in his treatment of the various species described by Gould, Reeve, Hombron and Jacquinot, and himself. In the first volume of his "Monographia Heliceorum," he simply repeats Gould's description and varieties. In his third volume he restricts and redescribes Gould's species, and adds to its synonymy *H. turricula*, Homb. and Jacq., and removes Gould's var. *b*, together with *H. excavata*, Homb. and Jacq., to the synonymy of *H. Jacquinoti*, Pfr., and cites Tahiti and Marquesas as habitats. On the same page he describes *H. cavernula*, Homb. and Jacq., with *H. coarctata*, Pfr., as a synonym. In the fourth volume he eliminates *H. turricula* from the synonymy of *H. bursatella*, and removes *H. excavata* from *H. Jacquinoti* to Gould's species. He also shifts *H. cavernula*, Homb. and Jacq. (not of Pfr.), to the synonymy of *H. Jacquinoti*. His *H. cavernula* (not of Homb. and Jacq.) he refers to *H. streptaxon*, Rve., and quotes *H. coarctata*, *H. turricula* and Gould's *H. bursatella*, var. *b* and *c*, as synonyms of Reeve's shell. In the fifth volume he doubts *H. cavernula*, H. and J., being synonymous with *H. Jacqui-*

noti, and describes a new species under the name of *H. Heynemanni*, the commonest form inhabiting all the valleys near the principal harbors at Tahiti, and undoubtedly included among Gould's varieties of *bursatella*. In the seventh volume he doubts *H. coarctata* and *H. turricula* being synonyms of *H. streptaxon*.

Mr. Pease, in his list of Polynesian land shells (P. Z. S., 1871), refers *H. coarctata*, *H. excavata*, *H. streptaxon* and *H. turricula* to the synonymy of *H. bursatella*, and adds *H. cavernula* to the synonymy of *H. Jacquinoti*, Pfr. He also records *H. Heynemanni*, Pfr., and *H. Oceanica*, Le Guill., as distinct species, unknown to him. He doubts *H. Jacquinoti*, which Pfeiffer assigns to the Marquesas, being a Society Island species. I am inclined to believe it inhabits the Austral Islands, and not Marquesas.

L. BURSATELLA, Gould.

Helix bursatella, Gould (part), Proc. Bost. Soc. Nat. Hist., 1846, p. 175; Expl. Ex. Shells, p. 51 (part). Pfeiffer, Mon. Hel., i, p. 185 (part); iii, p. 142 (as restricted). Chemnitz. ed. 2d, Pl. CXXV, figs. 23–25. (*Endodonta*) Albers, Die Hel., p. 189. Reeve, Conch. Icon., Pl. CXI, fig. 635. (*Pitys*) H. and A. Adams, Gen. Moll., ii, p. 113. (*Endodonta*) Paetel, Cat. Conch., p. 91.

Helix turricula, Hombron and Jacquinot, Voy. Pol. Sud, Mol., Pl. VI, figs. 21–24.

Pitys bursatella, Pease (part), Proc. Zool. Soc., pp. 452, 475. Frauenfeld, Verh. Zool. Bot. Ges. Wien, 1869, p. 873.

In 1861, I gathered numerous examples of this species at Tahiti, but, as previously mentioned, my specimens of *Libera* were more or less intermixed, so I cannot state the precise locality where I took the specimens.

It may be distinguished by its semiglobose form, rather elevated dome-like spire, crowded, slightly arcuate riblets, flattened and rather smooth base, and the absence of spiral striæ. There are six to seven internal laminæ.

Major diam. 7½ mill.

L. COARCTATA, Pfeiffer, Plate II, fig. 10.

Helix bursatella, Gould (part), Proc. Bost. Soc. Nat. Hist., 1846, p. 175; Expl. Ex. Shells, p. 51.

Helix coarctata, Pfeiffer, Proc. Zool. Soc., 1849, p. 128; Zeit. Malak., 1849, p. 74. (*Endodonta*) Albers, Die Hel., p. 89.

Helix cavernula, Hombron and Jacquinot, Voy. Pol. Sud, Moll., Pl. VI, figs. 33–36. Chemnitz, ed. 2d., No. 781, Pl. CXXV, figs. 29–31. Pfeiffer, Mon. Hel., iii, p. 143. (*Pitys*) H. and A. Adams, Gen. Moll., ii, p. 113.

Helix streptaxon, Reeve, Conch. Icon., Pl. CXII, fig. 641. Pfeiffer, Mon. Hel., iv, p. 154. (*Endodonta*) Paetel, Cat. Conch., p. 95.

Common and diffused throughout several valleys on the north and east side of Moorea. On the ground in forests.

The spiral, raised striæ will readily distinguish it from *L. recedens* and *L. gregaria*, inhabiting the same island. They vary some in the height of the spire, and some have the riblets more distant than others. Examples with receding body-whorl are not infrequent. A variety (local) occurs which is uniform whitish.

L. RETUNSA, Pease, Plate II, fig. 8.
Helix retunsa, Pease, Proc. Zool. Soc., 1864, p. 670. Pfeiffer, Mon. Hel., v, p. 220.
Pitys retunsa, Pease, Proc. Zool. Soc., 1871, p. 475.

Mr. Pease's type specimens were collected by me on the south side of Tahiti, where it is not uncommon beneath rotten wood.

This remarkable shell differs from the preceding species in having rounded whorls, the last one neither carinated nor angled, and in the absence of the lamina in the palate. The spire, which is more or less elevated, is truncate, dome-shaped; whorls 6–7, cancellated with fine, crowded, revolving, raised lines, and radiating, distant, delicate, obliquely curved riblets. Parietal region with a single, elongate lamina, and a small one on the columella. Color whitish or yellowish horn-color, above tessellated, and the base with waved, radiating stripes, reddish brown.

Diam. 4, height 2–3 mill.

L. HEYNEMANNI, Pfeiffer, Plate II, fig. 9.
Helix Heynemanni, Pfeiffer, Mal. Blat., 1862, p. 151; Mon. Hel., v, p. 219.
Pitys Heynemanni, Pease, Proc. Zool. Soc., 1871, p. 475.
Patula Heynemanni, Schmeltz, Cat. Mus. Godeff., v, p. 93.
Helix bursatella, Gould (part), Proc. Bost. Soc. Nat. Hist., 1846, p. 175.

Very abundant in several valleys on the northwest part of Tahiti, where they live beneath loose stones and decaying wood.

There is not the slightest doubt in respect to this common species having been collected by Wilkes' naturalists, who carefully explored that part of Tahiti. Examples sent to Mr. Pease were by him referred to *bursatella*, Gould. Some sent to one of my English correspondents were also referred to Gould's species. On the other hand, a lot forwarded to the Museum Godeffroy, were by Prof. Mousson identified with Pfeiffer's *Heynemanni*.

Although Mr. Pease quotes *Heynemanni* as distinct, yet it is evident from his remarks on the Tahiti species that he did not identify the shells received from me as being that species.

It may be characterized by its exceedingly fine transverse and revolving raised striæ, which are so closely set as to impart a silky lustre to the shell. Pfeiffer, who does not allude to the concentric lines, merely says "leviter striata." The spire, which varies slightly in height, is depressed dome-shaped, whorls 6–7, nearly planulate, submargined, the last one *not* descending and acutely carinated. The convex base is cancellated the same as above. There are two parietal laminæ, the lower one the shorter, four in the palate, three conspicuous, deep-seated, beneath the keel, and one above not so conspicuous and sometimes obsolete. A small one on the columella. Color whitish or luteous, rarely uniform brownish, generally profusely spotted and undulately striped with chestnut-brown. The revolving striæ are sometimes nearly obsolete.

Diam. 5–5½, height 2½–3½ mill.

L. GREGARIA, Garrett, Plate II, figs. 6, 6 *a*, 6 *b*.

Shell small, umbilicated, solid, orbicular, depressed, not shining, closely and obliquely striated with small, regular, slightly biarcuate, rough riblets, which are more crowded on the base; whitish corneous, tessellated and undulately rayed with chestnut-brown; spire depressed dome-shaped, apex flattened; suture moderately impressed; whorls seven, slightly convex, narrow, slowly and regularly increasing, last one acutely carinated, sometimes descending a little below the penultimate whorl; base flatly convex, concave on the boundaries of the umbilicus; umbilicus (in adolescence) wide, exposing all the whorls, one-third the major diameter of the shell; in adults strongly constricted by an acute expansion of the last whorl; aperture small, oblique, depressed, irregular rhomboid-luniform; laminæ 5–6, two in the parietal region, elongate, of equal length, one columellar, two in the palate beneath the keel, short, conspicuous, one above the keel, inconspicuous and occasionally absent; peristome acute, straight, basal margin continuous with the acute umbilical constriction; columella short, concave, receding.

Major diam. 7, height 3½ mill.

Hab.—Moorea.

I discovered two colonies of this very distinct species in two valleys on the south-west part of Moorea. They were congregating in immense numbers on the under side of loose stones. Though carefully searched for, I failed to detect them in any other part of the island. No other species of this genus occurs in the same location with the shells under consideration.

With the exception of a slight difference in the elevation of the spire, they are very uniform in all their specific characters.

L. RECEDENS, Garrett. Plate II, fig. 7.

Shell small, umbilicated, not shining, rather solid, depressed, orbicular, with thin, crowded, slightly oblique, rough, elevated striæ, which are finer and more closely set on the base; dark chocolate-brown, with or without yellowish horn-colored tessellations and undulated stripes; spire depressly convex, apex flattened; suture linearly impressed; whorls seven, very little convex, narrow, slowly and regularly increasing, last one carinated, gradually descending below the periphery of the penultimate whorl; base convex, concavely indented at the axis; umbilicus (in adolescence) freely exposing all the whorls, a little more than one-third the greater diameter of the shell; in adults the umbilicus is constricted to about one-third that of adolescent examples; aperture small, depressed, oblique, irregularly rhomboid-luniform; laminæ six, two on the parietal region, elongate, the lower one deeply seated, a stout one on the columella, two short conspicuous ones in the palate between the keel and base, and a less conspicuous one above; peristome thin, straight, the lower margin continuous with the umbilical constriction; columella short, concave, receding.

Major diam. $5\frac{1}{2}$, height $2\frac{1}{2}$ mill.

Hab.—Moorea.

Very abundant beneath decaying vegetation, and restricted to the lower part of one valley on the west side of Moorea, and the only species found in that location.

The deflection of the last whorl below the periphery of the penultimate whorl, which is an accidental character in some of the species, *is constant* in this. The persistence of this feature, together with the fine, crowded striæ, dark color, absence of concentric lines, as well as difference in the internal laminæ, are its most essential characters.

Genus ENDODONTA, Albers.

This genus was instituted by Dr. Albers for a peculiar group of small Helices inhabiting the Sandwich Islands, the type of which is *Helix lamellosa*, Fer. Five species are known to inhabit that group; all of which are characterized by their lenticular form, acutely carinate periphery, large umbilicus, subrhomboid or securiform aperture, which is garnished with two parietal, one columellar, and three or four palatal laminæ.

Some of the Society Islands species are very closely related to the Sandwich Islands shells in shape, and the existence of one or more deeply seated laminæ in the palate; the latter character was overlooked by Pfeiffer, Pease, and the writer, when describing the different species inhabiting the group.

They are all very widely umbilicated, the last whorl carinated or angulate, and all, with one exception, have one or two parietal laminæ; the lower one, when two are present, is always shorter, and owing to its being deeply seated has hitherto been overlooked. The aberrant species are *Helix fabrefacta*, Pease, which is without laminæ, and *H. obolus*, Gould, which has a single one on the parietal region; otherwise the shape of the shells is quite similar to the others. The laminæ are not so prominent as in the typical species, and are distinctly represented in the different stages of growth, but, excepting those on the last two whorls, are gradually absorbed by the animal.

They inhabit all the Islands except Tahiti and Moorea, where they are represented by a distinct group of Helices, the type of which is *Helix bursatella*, Gould. They are all ground species, and are very numerous in certain favorable localities.

E. Huaheinensis, Pfeiffer. Plate II, figs. 26, 26 *a*, 26 *b*, 26 *c*.

Helix Huaheinensis, Pfeiffer, Zeit. Mal., 1853, p. 55; Mon. Hel., iii, 640.

Endodonta Huaheinensis, Pfeiffer, Vers., p. 129. Albers, Die Hel., ed. 2, p. 9. Pease, Proc. Zool. Soc., 1871, p. 474. Paetel, Cat. Conch., p. 91.

Patula Huaheinensis, Schmeltz, Cat. Mus. Godeff., v, p. 93.

This species is abundant in all the large valleys on Huaheine. Though widely diffused over the island, it has not, so far as known, been detected in any other location.

On breaking away about one-fourth or one-third of the last whorl, there may be observed a second lamina on the penultimate whorl, and two or three in the palate beneath the keel, and frequently one above. On exposing these deeply seated laminæ, the aperture is precisely like the Sandwich Islands types.

This shell may be distinguished by its depressed convex spire, flattened whorls, and the color, which is dull corneous, is profusely spotted and striped with reddish brown. In adults the peristome is gently and regularly curved from the termination of the keel to the columellar region.

E. FICTA, Pease. Plate II, figs. 25, 25 *a*, 25 *b*.

Helix ficta, Pease, Proc. Zool. Soc., 1864, p. 669. Pfeiffer, Mon. Hel., v, p. 223.

Endodonta ficta, Pease, Proc. Zool. Soc., 1871, pp. 455, 474.

This species is confined to Tahaa, not "Raiatea," as stated by Pease, where it occurs plentifully, associated with *E. fabrefacta*.

Besides the constant single parietal lamina mentioned by Pease, there is a second one deeply seated in the palate between the keel and base of the shell.

As compared with the preceding species, which it closely resembles in texture, color and markings, it is larger, has one more whorl, the umbilicus wider and its margin more acutely angulate, and the aperture more decidedly rhomboidal in outline. The upper surface of the last whorl is more or less distinctly concave or sulcated next to the suture, a character not observed in *Huaheinensis*.

E. FABREFACTA, Pease.

Helix fabrefacta, Pease, Proc. Zool. Soc., 1864, p. 669. Pfeiffer, Mon. Hel., v, p. 190; vii, p. 210; Novit. Conch., fasc. xxxvi, p. 505, Pl. CVIII, figs. 28–31.

Endodonta fabrefacta, Pease, Proc. Zool. Soc., 1871, p. 474.

Patula fabrefacta, Schmeltz, Cat. Mus. Godeff., v, p. 207.

Patula conicava, "Mousson," Schmeltz, Cat. Mus. Godeff, iv, p. 72. Paetel, Cat. Conch., p. 89.

Helix conicava, Pfeiffer, Mon. Hel., vii, p. 480 (name only).

A common species, confined to four large valleys on Raiatea, and one on the east coast of Tahaa. On the ground in forests.

This is one of the aberrant species previously alluded to, which in the type is entirely destitute of internal laminæ. In every other particular, it cannot be distinguished from the typical *Endodonta*.

Dr. Pfeiffer has given an accurate description and figures of this species in the "Novitates Conchologicæ."

It attains a larger size than given by the above author. My largest examples are nearly 9 mill. in the greatest diameter by 4 in height. They vary some in the elevation of the spire, and the brown spots are occasionally absent. The spire is always more or less concave in outline, and the broad umbilicus is funnel-shaped, with planulate walls. In adults there are eight flat whorls, the last three subconcave, and the aperture is a nearly equally four-sided square.

Var. PICEA, Garrett.

This variety, which I have distributed to my correspondents under the name of *Pitys picea*, differs none from the type, except in being smaller and the parietal wall unilaminate. The aperture is also vertically narrower.

Not infrequent on the west side of Raiatea.

E. OBOLUS, Gould.

Helix obolus, Gould, Proc. Bost. Soc. Nat. Hist., 1846, p. 175; Expl. Ex. Shells, p. 53, fig. 50. Pfeiffer, Mon. Hel., i, p. 187.
Endodonta obolus, Albers, Die Hel., ed. 2d, p. 90. Pease, Proc. Zool. Soc., 1871, p. 474.
Pitys obolus, H. and A. Adams, Gen. Moll., ii, p. 114.
Patula obolus, Schmeltz, Cat. Mus. Godeff., iv, p. 72. Paetel, Cat. Conch., p. 93.
Helix acetabulum, Pease, Proc. Zool. Soc., 1861, p. 242. Pfeiffer, Mon. Hel., v, p. 222.
Endodonta acetabulum, Pease, Proc. Zool. Soc., 1871, p. 474.
Pithys? celsa, Pease, Jour. de Conch., 1870, p. 396.
Endodonta celsa, Pease, Proc. Zool. Soc., 1871, pp. 455, 474.
Helix celsa, Pfeiffer, Mon. Hel., vii, p. 260.
Patula Barffi, Garrett, Schmeltz, Cat. Mus. Godeffr., v, p. 93.
Patula intermixta, "Mousson," Schmeltz, Cat. Mus. Godeff., v, p. 93.

This variable species, which is confined to Raiatea and Huaheine, is plentiful and widely diffused over the two islands.

Dr. Gould's habitat, "Taheiti," is undoubtedly wrong. Having personally explored every valley on Tahiti and Moorea, I did not find a single example of this type of Helices. His specimens were probably from Raiatea. Dr. Gould describes it as follows:—

"T. parva, discoidea, deorsum compressa, supra planulata, infra concava, radiatim minutissima et inæqualiter striata, fusco-ferruginea, piceo tessellata; spiræ anfr. $5\frac{1}{2}$, supra excavati, ultimus superne costato-carinatus; apertura subrhomboidea, fauce lamella unica secundum anfractum penultimum volventi. Lat. $\frac{1}{6}$, alt. $\frac{1}{30}$ poll." (Gould).

The above description accords well with the shells under consideration, and the "supra excavata" agrees better with the Raiatea shells than those from Huaheine. But the above author's reference to *Planorbis vortex* as similar in shape renders the identification beyond doubt.

I am fully convinced that Pease's *acetabulum* is specifically the same as Gould's species.

Mr. Pease's diagnosis, which is rather obscure, I reproduce:—

"T. parva, planorboidea, superne leviter convexa vel plana; umbilicus amplus, cyathiformis; utrinque subtiliter radiato-striata, ad peripheriam et umbilici marginem carinato costata, subtus subobsolete costata; anfr. 6, carinato-rotundati, seriebus radiantibus pilorum brevium muniti, suturis bene impressis. Apertura subrhomboidea, lamella unica in anfr. penultimo munita. Testa saturati castaneo et fulvo fusco tessellata. Diam. 5, axis 2 mill." (Pease).

I collected Mr. Pease's type specimens at Huaheine; and, though he was well aware of the fact, yet he gave the wrong habitat "Tahiti" to this and several other new species obtained on the former island.

The base is never "carinato-costata." It is rounded or faintly angulate. His "pilorum-brevium" exists in immature examples only.

Eight years after receiving from me a lot of Raiatea specimens of this species he published his "*Pithys? celsa*" (l. c.). His description is as follows:—

"Testa discoidea, late umbilicata, radiatim tenuiter, regulariter rugoso striata, concentrici irregulariter sulcata aut tenuiter costata; spira depresso elevata, convexa; anfr. 7, rotundato-convexi, plerumque angulati, ultimus ad peripheriam rotundatus; umbilicus $\frac{4}{10}$ diametri occupans; apertura vix. obliqua subcircularis, lamella unica volvente instructa; perist. simplex rectum; radiatim fusco et albido tessellata. Diam. 6, alt. 3 mill." (Pease).

The following year he redescribes it under the name of "*Endodonta celsa*" (l. c.), without referring to his former diagnosis. I repeat his description:—

"T. orbicularis, solidiuscula, late umbilicata, tenuissime radiatim creberrime striatula, rufo et albido pallide tessellata; spira elevata, apice obtusiusculo, nucleus rufescenti-fuscus, sutura bene impressa; anfr. 7, convexi, interdum concentrice elevato-striati, rarissime sulcati aut angulati, ultimus ad peripheriam obtuse angulatus, subtus rotundatus; apertura obliqua, fere circularis, lamella unica in anfr. penultimo munita. Diam. 7, alt. $3\frac{1}{2}$ mill." (Pease).

He gives the correct habitat "Raiatea." It will be observed that there is some discrepancy between the two descriptions of *celsa*, proving it to be a variable species. His measurement, 6 mill., is correct, but his last one, 7 mill., is larger than any specimen known to me.

Having a second time gone over the same ground and collected hundreds of specimens, both on Raiatea and Huaheine, I do not hesitate, after a careful study of the numerous examples, to add both *acetabulum* and *celsa* to the synonymy of *obolus*.

I am not positive, but I think I am correct in referring Mousson's *intermixta* (which I collected at Raiatea) to Gould's species. My *Barffi*, MS, is the Huaheine shell.

This species, in the shape, and the absence of palatal laminæ, is nearly intermediate between *Endodonta* and those species of *Patula* with the single parietal lamina.

The height of the spire varies from a perfect plane to a depressed cone, hence a deeper or shallower umbilicus. They also vary in the distinctness of the periphery-keel, and some have that part of the shell obtusely angular, without the slightest indication of a keel. Rarely they exhibit slight traces of spiral riblets, but the shallow sulcation on the upper surface is not infrequent. Immature shells have usually radiating, distant, thin, deciduous, lacerated or hirsute membraneous riblets both above and beneath. The color is greenish corneous, with small spots and stripes of reddish brown. Raiatea examples are more variable than Huaheine specimens. The whorls, 6–7, are marked by fine, not smooth, striæ of growth. The very wide umbilicus is more than half the diameter of the shell. The base of the last whorl is either rounded or slightly angulated, and the aperture is subcircular in full-grown shells or subrhomboidal in immature examples.

E. CRETACEA, Garrett. Plate II, figs. 27, 27 *a*, 27 *b*.

Pitys ficta, Garr. (not of Pease). Schmeltz, Cat. Mus. Godeff., v, p. 223 (ex. Garr.).

Shell very broadly umbilicated, rather solid, depressed, lenticular, finely striated, dull whitish, with small, irregular, scattered brown spots; spire depressed convex, or subplanulate, with flat outlines; apex subacute; suture linear; whorls 6½–7, planulate, narrow, slowly and regularly increasing, the last two slightly concave, acutely carinate on the periphery, not descending in front; beneath the keel oblique, planulate; base acutely angulate; umbilicus very large, funnel-shaped, with planulate walls; aperture oblique, quadrate; parietal region with a single revolving lamina, and one in the throat between the keel and basal angle; peristome simple, acute, straight; columella simple.

Major diam. 6, height 2 mill.

Hab.—Borabora Island.

Common, but very local and restricted to the above island, where they live on the ground in forests at an altitude of about 600 feet above sea-level.

It is shaped and colored nearly the same as *fabrefacta*, but is smaller, more depressed, and the last whorl is not so deep, and the flattened space between the two angles is more oblique. They also differ in the outlines of the spire, and the two internal laminæ are constant.

Many of the adult shells have the umbilicus covered with a thin brownish yellow membrane, which, in all I examined, was perforated. Probably the animal, as in *Libera*, oviposits into the umbilicus and covers the opening with the membrane, and the perforations were made when the young escaped. I searched, in vain, for intact membranes in hopes of discovering either the eggs or young shells. This peculiar feature has, so far, only been observed in the Borabora shells. I copy the following from the Jour. de Conch., 1865, p. 395:—

"L'Endodonta lamellosa, Fér., dépose ses œufs dans l'ombilic, ainsi qu'une autre espèce des îles Sandwich communiquée par M. Harper Pease: dans cette dernière l'ombilic était couvert d'une sorte d'épiphragme" (O. A. Mörch).

E. TANEÆ, Garrett.

Pitys Taneæ, Garr., Proc. Cal. Acad. Sciences, 1872, iv, p. 204. Proc. Acad. Nat. Sci. Phil., 1873, p. 234, Pl. III, fig. 65.
Patula Janeæ, Schmeltz, Cat. Mus. Godeff., v, p. 93. (Typ. err.)
Helix Janeæ, Pfeiffer, Mon. Hel., vii, p. 481. (Name only ex. Schmeltz.)
Helix Taneæ, Pfeiffer, l. c., p. 482. (Name only.)
Helix Boraborensis, Pease, MS., Mus. Pease, 1863.

Very abundant and restricted to Borabora and Maupiti, where they live on the ground in forests.

When I wrote my description of this species I had only half a dozen specimens of *Boraborensis* named from Pease's types. Having subsequently gathered several hundred of the latter species at Borabora, I find the two species gradually intergrade. Maupiti specimens are remarkably uniform in shape, sculpture and coloration. The Borabora shells, on the contrary, are subject to considerable variation in all the above characters. In order to incorporate the characters of the latter, I redescribe it as follows:—

Shell widely umbilicated; depressed, lenticular, rather thin, corneous or brownish horn-color, irregularly spotted and rayed with rufus-brown, rarely unicolored; sculpture consisting of very small, rude, crowded, oblique, subarcuate, raised striæ, with remote larger ones intermixed; the latter sometimes absent in the Borabora shells, and in the immature they are frequently membraneous and lacerated; spire more or less convex, sometimes nearly planulate, rarely depressly conoid; apex mucronated, generally, suture lightly impressed, occasionally margined by the continuation of the periphery-keel. Whorls $5\frac{1}{2}$–$7\frac{1}{2}$, convex or subplanulate, very narrow, slowly and regularly increasing, last one not deflected in front, rarely sulcate above, periphery acutely carinate; base more or less distinctly angulate, rarely rounded; umbilicus funnel-shaped, a little more than a third the greater diameter of the shell. Aperture oblique, irregularly rhomboid-luniform; parietal region with two laminæ, the lower one short and rarely visible without breaking away a portion of the peristome; palate with two to four deeply seated lamelliform teeth, the one above the keel sometimes absent; peristome thin, simple, straight; columella not expanded.

Major diam. $4\frac{1}{2}$, height $1\frac{1}{2}$ mill.

The above measurement is the average size of Maupiti specimens. The Borabora shells are sometimes a trifle larger, and some have the spire more elevated. The young are occasionally dark brownish, with rounded whorls, which are conspicuously undulated, and the striæ very uniform. Individuals are not infrequent which have the whorls more tightly coiled, the striation finer and very uniform in size. In the latter, the body-whorl is deeper and the keel more obtuse.

The umbilical membrane or diaphragm, alluded to in my remarks on *cretacea*, is frequent in the Borabora shells, but not observed in those from Maupiti.

Genus STENOGYRA, Shuttleworth.

S. Tuckeri, Pfeiffer.

Bulimus Tuckeri, Pfeiffer, Proc. Zool. Soc., 1846, p. 30; Mon. Hel., ii, p. 158; (*Opeas*) Vers., p. 156. Reeve, Conch. Icon., Pl. LXVIII, sp. 481; (*Opeas*) Cox, Mon. Aust. Land Shells, p. 69, Pl. XIII, fig. 9. Brazier, Quar. Jour. Conch., i, p. 272. Garrett, Jour. Acad. Nat. Sci. Phila., 1881, p. 393.

Stenogyra Tuckeri (*Opeas*), Albers, 265. (*Opeas*) Frauenfeld, Verh. Zool. Bot. Wien., xix, p. 873. Pease, Proc. Zool. Soc., 1871, p. 473.

Bulimus junceus, Gould, Proc. Bost. Soc. Nat. Hist., 1846, p. 191; Expl. Ex. Shells, p. 76, fig. 87. Pfeiffer, Mon. Hel., ii, p. 220.

Stenogyra juncea, Mousson, Jour. de Conch., 1869, p. 340; 1870, p. 126; 1871, p. 15; 1873, p. 106. Pease, Jour. de Conch., 1871, p. 93; Proc. Zool. Soc., 1871, p. 473. (*Opeas*) Paetel, Cat. Conch., p. 104. Schmeltz, Cat. Mus. Godeff., v, p. 90. Garrett, Proc. Acad. Nat. Sci. Phila., 1879, p. 19.

Bulimus Walli, Cox, Cat. Aust. Land Shells, p. 24. Pfeiffer, Mon. Hel., vi, p. 99.

Stenogyra Upolensis, Mousson, Jour. de Conch., 1865, p. 175. (*Obeliscus*) Paetel, Cat. Conch., p. 104. Schmeltz, Cat. Mus. Godeff., iv, p. 29.

Bulimus Upolensis, Pfeiffer, Mon. Hel., vi, p. 100.

Stenogyra novemgyrata, Mousson, Jour. de Conch., 1870, p. 126. (*Subulina*) Paetel, Cat. Conch., p. 104. Schmeltz, Cat. Mus. Godeff., v, p. 90.

Bulimus novemgyratus, Pfeiffer, Mon. Hel., viii, p. 138.

A very common species, distributed throughout all the Polynesian islands, and extends its range to the East Indies. They range from near high-water mark to over 2000 feet above the level of the sea.

For further remarks on this species, see my paper on the Cook's Islands land shells, published in the Journal of the Academy of Natural Sciences of Philadelphia.

Genus PARTULA, Ferussac.

The genus *Partula*, so far as known, is restricted to the Pacific islands, ranging from the Marquesas throughout all the groups as far west as New Guinea; but is not found in New Zealand, nor New Caledonia, nor Australia. North of the equator, they occur at the Caroline, Pelew and Marianne Islands, the latter being the northern limit of the genus. They are entirely absent from the Sandwich group, where they are represented by the closely allied genus *Achatinella*. Neither do they occur on any of the low coral islands.

It is now a well-known fact that each group, with one exception, is inhabited by peculiar or endemic species. The solitary exception is *P. hyalina*, which has its metropolis in the Austral Islands; is also found on Mangaia, one of the Cook's group, as well as at Tahiti.

The Society Islands, which are inhabited by nearly one-half of the known species of *Partula*, may be regarded as the central point of distribution of the genus. Out of fifteen subgenera lately established by Dr. Hartman, ten are found in the group, and, besides the type, which is peculiar, seven of his subgeneric types are found nowhere else. It is also the only group possessing strictly terrestrial or ground species; and nowhere else do we find so great a variety of forms in the shape of the shells, which varies from the almost globose *P. Hebe* to the slender *P. elongata*. It is no less noteworthy that nearly one-half of the species have a "button-like" tooth on the parietal wall, and some have a tooth-like projection on the inner margin of the peristome, which gives the aperture an auriculate shape—a feature found in no other group. The Society Islands shells are also the most variable in color, and more than half of the species are more or less spirally banded—a character rarely found in the extra-limital species.

The distribution of the various species throughout the group presents many very interesting features, which are, indeed, worthy of more attention than I am able to give to the subject. With three exceptions, each island is inhabited by distinct species, and some possess peculiar types or subgenera. The specific centre or metropolis of nearly all the species is clearly defined by the profusion or concentration of individuals in limited areas. In some instances we find two, rarely three, species having their centres of distribution in a single valley, and in some cases one is entirely restricted to its headquarters, whilst the others have spread into two or more valleys.

On Tahiti, the largest island in the group, we find eight species only, six of which are endemic. One (*P. clara*), which has a limited range, appears to be gradually becoming extinct. Four species (*P. filosa, nodosa, producta* and *stolida*) are each restricted to a single valley. All the above species are well-defined, and exhibit but little variation. On the contrary, *P. Otaheitana*, which has its centre of distribution in Fautaua valley, has spread all round the island, and is subject to so much variation that no less than fourteen species have been proposed for the different forms. Two species (*P. hyalina* and *attenuata*) are common to other islands; the former, as before mentioned, is found in the Austral and on one of the Cook's group; the latter occurs on Raiatea, but does not inhabit the two intermediate islands. It is a noteworthy fact that, notwithstanding both species have spread nearly all round Tahiti, yet they have not developed a single varietal feature, but, on the contrary, are remarkably uniform in all their specific characters. One would naturally suppose that the southern examples of *P. hyalina*, which are subject to lower temperature and different formation (*elevated coral reefs*), would have exhibited some degree of variation to distinguish them from the Tahitian specimens living in a higher temperature on a volcanic island.

Here we have three species ranging round the island, and all subject to the same conditions of life, yet two have not shown the slightest tendency to depart from the typical forms, and the other, which is very variable in its metropolis, has developed many local varieties. The above facts, which are common to other species, seem to suggest that physical conditions are not the primary cause of variation, but that it is the operation of some unknown law.

Moorea, which is separated from Tahiti by a channel only eight miles wide, is inhabited by four species found nowhere else. One (*P. tæniata*), which has its metropolis in a large valley on the north coast, is, like *P. Otaheitana*, a very variable species, and has spread round three-fourths of the island, and, like the latter species, has developed local varieties which have received distinct names. *P. lineata*, which inhabits that part of the island *not* occupied by *tæniata*, is nearly as variable as that species. *P. elongata*, which is confined to the same portion of the island as *lineata*, is less variable, and where it comes in contact with *tæniata* we find hybrids between the two so common as to suggest a certain degree of fertility in the intermediate forms. *P. Mooreana*, which is always reversed, is confined to a single valley and shows but slight variation.

One peculiar feature in the Tahiti and Moorea shells is the profusion of sinistral forms which are entirely absent from the leeward islands in the group.

Huaheine, like Moorea, possesses four endemic species, all of a different type from those inhabiting the preceding two islands. Two (*P. arguta* and *annectens*) are restricted to two valleys, and the latter, like *P. clara*, appears to be gradually becoming extinct. Both species are remarkably uniform in all their specific characters. On the contrary, the other two species (*P. rosea* and *varia*) have spread nearly all over the island, and are subject to considerable mutation. It is worthy of remark that dentated species, which are so common at all the islands except Borabora, do not occur on Huaheine.

Raiatea, though only fourteen miles long and nearly half as broad, is inhabited by twenty species of *Partula*, being one-half of the number assigned to the whole group, and eighteen are found nowhere else. These, according to Dr. Hartman's divisions, include not only the type, but five out of his fifteen subgenera, two of which are peculiar to the island. Nearly all the species are remarkably prolific, and, with few exceptions, are subject to greater or less variation. Ten of these varieties being local, have usually been regarded as distinct species. Six species are strictly terrestrial. The fine large typical *P. faba*, which has its metropolis at Utuloa on the north end of the island, has spread into nearly all of the valleys, and is equally as variable in all parts of the island as in its headquarters. On the adjacent island of Tahaa we find the same species represented by distinct varieties. Two of the Raiatea species (*P. turgida* and *P. attenuata*), though having an extensive range, do not vary in a single feature; the former, like *P. clara* and *annectens*, seems to be dying out. Three species (*P. callifera*, *citrina* and *auriculata*) are restricted to single valleys, and the two former, like *turgida* and *attenuata*, are very uniform in color and shape. All the other species, though having special headquarters, have a greater or less range over two or more valleys, and ten species have produced local varieties.

Passing over the narrow lagoon to Tahaa, the latter about the size of Huaheine we find four endemic species, and, as before stated, two local varieties of *P. faba*; one occupying that part of the island nearest to the metropolis of the type, and the other, which is frequently dentated, is distributed over the remaining portion of the island. The beautiful *P. bilineata* is confined to a single valley on the eastern coast, and *P. planilabrum*, which has its headquarters in the large Haamene valley, just to the southward of the home of the former species, has established a colony in the valley on the north side of the one occupied by *P. bilineata*. *P. umbilicata*, which shares the metropolis of *planilabrum*, has, like that species, avoided intruding in the home of *bilineata*, but to the northward it occupies several valleys, slightly overlapping the northern range of *P. virginea*, which latter has its metropolis on the west coast, and, like *P. umbilicata*, ranges throughout several valleys north of its headquarters.

Borabora, the smallest island inhabited by *Partula*, possesses a single species of a peculiar type, which has spread nearly all over the island without developing a single local variety.

Hybrids between *P. elongata* and *P. tæniata*, and between *P. Garrettii* and *P. Thalia*, are so common where those species come in contact, that I am inclined to believe they possess a certain degree of fertility. I have also detected several hybrids between *P. faba*, var. *subangulata*, and *P. virginea*; one between the arboreal *P. imperforata* and the terrestrial *P. lugubris*; two between *P. lineata*, var. *strigosa*, and *P. tæniata*; about a dozen between the arboreal *P. faba* and the terrestrial *P. radiata*; a number between *P. faba* and *P. fusca*, and many between the latter and *P. navigatoria*, as well as many between the latter and *P. faba*. I failed to detect hybrids between the Tahitian species, and found none at Huaheine.

The examination of the animals of the various species has convinced me that they possess no reliable external features that will aid in their determination. The coloration in all the species varies from pale cinereous, through all the intermediate shades, to black or dusky slate. The arboreal species are generally lighter colored than the ground species, and have a more expanded creeping-disk. The animals of *P. arguta*, *annectens*, *turgida* and *attenuata*, have the ocular tentacles longer and more slender than the other species, and the exudation of mucus is much more copious and more viscid or tenacious than usual, resembling in that respect the same difference as exists between the typical Helices and the arboreal Naninæ.

P. OTAHEITANA, Bruguière.

Bulimus Otaheitanus, Bruguière, Ency. Meth., i, p. 347. Lamarck, Anim. sans Vert., Desh. ed., p. 281. Kuster, Pl. XIV, figs. 5–6. Pfeiffer, Mon. Hel., ii, p. 71, part.
Helix perversa, etc., Chemnitz, ix, p. 108, Pl. CXII, figs. 950, 951.
Helix Otaheitana, Dillwyn, Desc. Cat. Shells, ii, p. 935. Wood, Ind. Test., Pl. XXXIV, fig. 110.

Partula Otaheitana, Ferussac, Prod., p. 66. Reeve, Conch. Syst., ii, Pl. CLXXV, fig. 16; Conch. Icon., Pl. III, figs. 13 *a*, 13 *b*. Jay, Cat. Shells, 1839, p. 57. Pfeiffer, Mon. Hel., iii, p. 448. Paetel, Cat. Conch., p. 104. (*Helena*) Hartman, Cat. Part., pp. 9, 10, with woodcut; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 184.

Partulus Otaheitanus, Beck, Ind. Moll., p. 58.
Helix Vanicorensis, Quoy and Gaimard, Voy. Astrolabe, ii, p. 115, Pl. IX, figs. 12–17.
Bulimus Vanicorensis, Lamarck, Anim. sans Vert., Desh. ed., p. 282. Pfeiffer, Mon. Hel., ii, p. 71.
Partulus Vanicorensis, Beck, Ind. Moll., p. 57.
Partula Vanicorensis, Pfeiffer, Mon. Hel., iii, p. 446. Paetel, Cat. Conch., p. 104.
Bulminus isabellinus, Pfeiffer, Proc. Zool. Soc., 1846, p. 39; Mon. Hel., ii, p. 70.
Partula isabellina, Reeve, Conch. Icon., sp. 10, Pl. II, fig. 8 *b*. Pfeiffer, Mon. Hel., iii, p. 448. Paetel, Cat. Conch., p. 104.
Bulimus amabilis, Pfeiffer, Proc. Zool. Soc., 1846, p. 38; Mon. Hel., ii, p. 71.
Partula amabilis, Reeve, Conch. Icon., sp. 8, Pl. II, figs. 8*a*, 10. Pfeiffer, Mon. Hel., iii, p. 448. Pease, Proc. Zool. Soc., 1871, p. 473. Paetel, Cat. Conch., p. 104.
Partula rubescens, Reeve, Conch. Icon., Pl. III, fig. 12. Pfeiffer, Mon. Hel., iii, p. 446. Pease, Proc. Zool. Soc., 1871, p. 473.
Partula Reeveana, Pfeiffer, Proc. Zool. Soc., 1852, p. 137; Mon. Hel., iii, p. 447. Chemnitz, ed. 2d, Bul., Pl. LXV, figs. 10, 11.
Partula Taheitana, Gould, Expl. Ex. Shells, Pl. LXXXIV, fig. 91. Pease, Proc. Zool. Soc., 1871, p. 473. Paetel, Cat. Conch., p. 104. Schmeltz, Cat. Mus. Godeff., v, p. 92.
Partula lignaria, Pease, Proc. Zool. Soc., 1864, p. 671; 1871, p. 473. Pfeiffer, Mon. Hel., vi, p. 160. Paetel, Cat. Conch., p. 104. Schmeltz, Cat. Mus. Godeff., v, p. 92.
Partula rufa, Carpenter (not of Lesson), Proc. Zool. Soc., 1864, p. 675. (*Helena*) Hartman, Cat. Part., p. 10.
Partula affinis, Pease, Amer. Jour. Conch., 1867, p. 224; Proc. Zool. Soc., 1871, p. 473. Schmeltz, Cat. Mus. Godeff., v, p. 92. Pfeiffer, Mon. Hel., viii, p. 204.
Partula sinistrorsa, Pease, MS. Coll. Pease, 1863. Paetel, Cat. Conch., p. 104. Schmeltz, Cat. Mus. Godeff., v, p. 92. Pfeiffer, Mon. Hel., viii, p. 209. Gloyne. Quar. Jour. Conch., i, p. 337.
Partula sinistralis, Pease, MS. Coll. Pease, 1863. Paetel, Cat. Conch., p. 104. Pfeiffer, Mon. Hel., viii, p. 209.
Partula crassa, Pease, MS. Coll. Pease, 1863.
Partula brevicula, Pease, MS. Col. Pease, 1863.
Partula perversa, Pease, MS. Coll. Pease, 1863.
Partula turricula, Pease, MS. Coll. Pease, 1863 (not *turricula*, Pease, in Amer. Jour. Conch., 1872).
Partula varia, Carpenter (not of Broderip), Proc. Zool. Soc., 1864, p. 675.
Partula Pacifica, Hartman (not of Pfeiffer), Cat. Part., p. 10.
Partula diminuta, Hartman (C. B. Adams ??), l. c., p. 10.

The metropolis of the typical *Otaheitana* is about two miles up Fautana valley, on the northwest part of Tahiti, where it is very abundant on the trunks and foliage of trees and bushes. The above-mentioned valley being close to the principal harbor which was frequented by the early navigators, it was undoubtedly where Bruguière's type was obtained.

The Fautana shells, which are very variable in size, shape, and color, are never ornamented by spiral bands, and about one-third of the specimens are sinistral. The parietal tooth is nearly always present in the adults, and the peristome, though usually white, is frequently pinky flesh-color. The prevailing colors are straw-yellow, reddish fulvous, light chestnut, frequently with the spire more or less tinted with reddish and often with longitudinal strigations. The spire is more or less produced, and the aperture varies some in size and shape.

The shape of the shell varies from abbreviate-ovate to elongate-ovate, as the following measurements will show:—

Length 21, diam. 10 mill. Dextral sp.
Length 16, diam. 10 mill. Dextral sp.
Length 20, diam. 10 mill. Sinistral sp.
Length 16, diam. 9 mill. Sinistral sp.

All the old authors refer to sinistral forms. The elongated dextral shells were described under the names *Vanicorensis* and *Reeveana*.

In a valley about two miles west of Fautana, there exists in abundance the variety (?) *lignaria*, Pease, which, though described as dextral, is nevertheless very frequently sinistral. Though not attaining quite so large a size as the Fautana shells, it differs none in shape, but is usually darker colored and more strigated, as well as exhibiting one to three transverse reddish chestnut bands. The lip is always white, and the parietal tooth is very seldom absent. The inosculation with *Otaheitana* is so complete that it cannot be even separated as a well-marked variety.

To the eastward between Fautana and Papinoo valley, a distance of about eight miles, there are three valleys, all inhabited by Pfeiffer's *amabilis*, a sinistral form which has not a single feature to distinguish it from some of the large turreted Fautana shells. In the first valley, Pfeiffer's species, though not abundant, were very fine specimens. The next valley, known as Pirai, the metropolis of the small dextral *P. filosa*, which occupy the lower part of the valley, is, in the upper part, which trends towards the headquarters of *Otaheitana*, inhabited by the sinistral *amabilis*. A few immature examples were found which were banded like *lignaria*. The only dextral *Partula* taken in the two valleys were *filosa*, *attenuata* and *hyalina*.

In the next valley, called Haona, I found the dextral *P. affinis* abundant, and took a few of *amabilis*.

Both Dr. Pfeiffer and Reeve described the latter species from specimens in the Cumingian collection, and both quote Anaa, a low coral island, as its habitat. Having resided about five months on that island, and searched all parts for shells, I did not find a single *Partula* there, or on any other low coral island. Mr. Pease, in his list of Polynesian land shells, assigns it to Tutuila, one of the Samoa or Navigator Islands, but on what authority I do not know. The type is purely Tahitian. Dr. Paetel and Dr. Hartman are the only authors who give the correct locality. Though neither Pfeiffer nor Reeve allude to a parietal tooth, it is, however, very frequently present.

Pease's *affinis*, which cannot be separated from some of the small abbreviated forms of *Otaheitana*, occurs in greater or less abundance in all the valleys from Haona as far as the southeast end of Taiarapu peninsula, and round the opposite coast as far as Papieri on the southwest of Tahiti proper. In Papinoo I discovered a large colony of *affinis*, many of which had the pinky flesh-colored lip and sinistral form of *Otaheitana.* Far up in the same valley, though common, none but dextral forms were found, and out of thousands taken in the other valleys, not one sinistral example occurred to my notice. In a valley several miles from Papinoo I found a small colony of *affinis*, which were marked by three transverse reddish chestnut bands like *lignaria.* And most singular, no other banded specimens of *affinis* occurred to my notice in any other part of the island. It is the variety *dubia*, Pse., and by Carpenter erroneously referred to *varia.*

Reeve's *rubescens* = *turricula*, Pse., MS., is abundant in Papinoo, and occurs sparingly in all the valleys as far as the southeast end of the island. Like *amabilis* it cannot be separated from the sinistral turreted *Otaheitana*, inhabiting Fautana. It is always sinistral, never banded, and, though usually of a reddish tint, is frequently straw-yellow or fulvous, with or without a reddish or pinky apex. The lip is white or pinky flesh-color. Though described as edentate, some have a small parietal tooth. Reeve gave no locality, and Pfeiffer erroneously cites the Marquesas as its habitat.

Pease's *sinistrorsa* is confined to the south coast of Tahiti proper, where it exists in the greatest profusion in all the valleys and lowland forests for a distance of ten or twelve miles. In the valley which is the limit of the range of the dextral *affinis* I took several specimens of the sinistral *sinistrorsa.* The latter is invariably reversed, dentate or edentate, fulvous with three more or less diffused reddish chestnut bands. Reeve figures the same shell on Plate III, fig. 13*a*, as *Otaheitana.* Bandless varieties are frequent, and vary from straw-yellow to fulvous or light chestnut, frequently strigated and the lip white. The latter varieties differ none from the true *Otaheitana* of Fautana.

It is worthy of remark that in that part of the district of Papieri, occupied by *sinistrorsa*, is also the headquarters of the terrestrial *P. producta*, a dextral species, which is always edentate, and exhibits the fasciation of the former.

After passing to the westward of the range of the typical *sinistrorsa*, which presents the same features for a distance of ten or twelve miles, it suddenly exhibits a tendency to a change in its becoming more stunted, more solid, always dentated, and the bands, one to three, are sharply defined on a pale ground. It is the *sinistralis* of Pease, MS., and occupies two valleys.

In the next large valley, called Faahuaite, on the southwest coast, we find Pease's *crassa* (MS.), which is also a sinistral shell, always dentated, solid, more tightly coiled than *sinistrorsa*, and the body-whorl is more flattened. It is rarely marked by a single narrow submedian chestnut band. In the same valley, but more inland, occurs a smaller form, which is, I suppose, the *P. brevicula*, Pse., MS.

The following valley, named Punaavia, is the metropolis of the beautiful *P. nodosa*, which also exhibits three bands. Far above the restricted range of the latter, where the valley turns towards the head of Fautana, the home of the typical *Otaheitana*, I took a few examples of a *Partula*, similar to, but larger than *crassa*. The next valley is the habitat of *lignaria*.

Perhaps it may, by some, be suggested that I ought to have been more conservative in my treatment of the *Otaheitana* group, which, to say the least, is a very perplexing one to separate into species or even well-marked varieties. However, I think *P. affinis*, *rubescens*, *crassa*, *sinistrorsa*, and perhaps *lignaria*, may rank as varieties which intergrade with the typical *Otaheitana*. But those who believe that species, like genera, have no sharply defined boundaries, but are connected to others by transitial forms, will in all probability consider them distinct, but closely allied species. but of less value than *P. hyalina*, *filosa* and *nodosa*.

P. LINEATA, Lesson. Plate III, fig. 83.

Partula lineata, Lesson, Voy. Coquille, p. 324, Pl. VII, figs. 8, 9. Reeve, Conch. Icon., Pl. II, fig. 7. Pfeiffer, Mon. Hel., iii, p. 449. Carpenter, Proc. Zool. Soc., 1864, p. 675. Schmeltz, Cat. Mus. Godeff., iv, p. 72.

Partulus torosus, Beck, Ind. Moll., p. 57.

Partulus lineatus, Albers, Die Hel., p. 187.

Partula strigosa, Pfeiffer, Proc. Zool. Soc., 1856, p. 384; Malak. Blatt., 1856, p. 244; Mon. Hel., iv, p. 509.

Partula alternata, Pease, MS. Coll. Pease, 1863.

Partula vexillum, Pease, Amer. Jour. Conch., 1866, p. 198; 1867, p. 81, Pl. I, fig. 8; Proc. Zool. Soc., 1871, p. 473. Pfeiffer, Mon. Hel., viii, p. 196.

Partula nodosa, Carpenter (not of Pfeiffer), Proc. Zool. Soc., 1864, p. 675 (= *alternata*). Pease, Proc. Zool. Soc., 1871, p. 473 (part). Schmeltz, Cat. Mus. Godeff., v, p. 92 (part). Gloyne, Quar. Jour. Conch., i, p. 337.

Partula stenostoma, Hartman (not of Pfeiffer), Cat. Part., p. 10.

Partula suturalis, Hartman (Pfeiffer?), l. c.

This beautiful arboreal species is found in great profusion in Vaianai valley, on the southeast coast of Moorea, where it occurs in company with *P. Mooreana* and *P. elongata*. It also exists in considerable numbers in a small valley about two miles to the westward, associated with *P. tæniata* and *elongata*.

I first discovered this species in 1861, and obtained several hundred specimens, *all* collected on the eastern side of the stream that flows through the valley of Vaianai. They were *all* dextral, and were so described by Pease, under the name of *vexillum*. On a second visit, in 1875, I took over 2000 examples, *all* gathered on the *western* side of the stream, and was surprised to find many sinistral forms among them. At the same time I found about a dozen specimens, *all* sinistral, in a large semicircular valley on the opposite side of the island. They were probably stragglers from Vaianai.

It is noteworthy that no reversed *Partulæ* were found in any other part of the island except on the western side of the stream in Vaianai, and the above-mentioned stragglers taken on the opposite coast. The same side of the stream is also the home of the sinistral *P. Mooreana*.

Several miles to the eastward of Vaianai, in a large valley named Oahumi, it is found equally as abundant as in the former location. The Oahumi shells, which are slightly modified (= *strigosa* = *alternata*), gradually inosculate with *lineata*. It occurs, also, sparingly in a valley more to the eastward, where it is associated with *P. tœniata* and *striolata*.

The type is luteous, or straw-yellow, rather shining, and girdled by two or three narrow, equidistant reddish chestnut bands. The shell is comparatively thin, compressly perforated, more or less wrinkled by incremental striæ, and the fine spiral incised lines are generally obsolete on the last whorl. The produced spire is a trifle more than half the length of the shell. The rather small aperture is truncately oval, and the parietal tooth is seldom absent. The white peristome is rather thin, moderately expanded, slightly reflected, lightly labiated within, and rarely with a slight sinus above. The columellar lip is receding above at its junction with the parietal wall.

Length 19, diam. 10 mill., which are about the average dimensions.

The following color-varieties occur:—

Var. *a.* Uniform chestnut-brown, sometimes approaching blackish brown, with a pale sutural line. Rare.

Var. *b.* Dark chestnut-brown, with a wide, median, luteous band on the body-whorl. Rare.

Var. *c.* Luteous or straw-yellow, with a very broad, deep, chestnut band on the middle of the body-whorl. Rare.

Var. *d.* Luteous, with faint, longitudinal, light fulvous-brown strigations. Common.

The sinistral examples, of which I obtained about fifty, exhibit the same variation as the dextral shells.

Contrary to the opinion of Messrs. Pease and Hartman, I follow Reeve, Pfeiffer and Carpenter in referring this species to Lesson's *lineata*, which that author erroneously accredited to Oualan or Strong's Island, one of the Caroline group. Lesson either collected his specimens at Moorea, or he received them from some of the foreign residents at Tahiti, and, as was *too* frequently the case with the naturalists of the exploring expeditions, had forgotten the correct habitat.

The following is a translation of Lesson's brief description:—

"Shell perforated, oblong-oval, luteous, with two fulvous bands; spire conical; whorls six, slightly convex, last one as long as the spire; aperture oval; peristome expanded; columellar margin much thickened within. Length 8, diam. 5 lines. *Hab.*—Oualan Island."

So far as the description goes, it coincides with the pale, banded, edentate Moorea shells.

Reeve describes it as follows:—

"Shell acuminately oblong, umbilicated, rather thin, whorls six in number, spirally very finely striated, light fulvous, subtransparent, encircled with two distant chestnut bands. Lesson, Voyage de la Coquille, p. 324, Plate VII, figs. 8, 9. *Hab.*—Friendly Islands" (Reeve).

Like Lesson, he does not mention the parietal tooth, which is well-expressed in his figure. His description is from examples in the Cumingian collection, and is certainly the Moorea shell. His habitat, "Friendly Islands" = Tonga, *is* incorrect. Only one species (*P. subgonocheila*) inhabits that group.

Pfeiffer, in his "Monographia Heliceorum," vol. iii, gives a more detailed description of *lineata*, also from specimens in Cuming's collection, and cites "Onalan et Eimeo" (= Moorea) as location, but in his subsequent volumes omits the latter location. Like the two former authors, he does not allude to the parietal tooth. However, he makes the same omission in two other dentated species.

A careful comparison of Pfeiffer's descriptions of *P. stenostoma* and *lineata* has convinced me that they cannot refer to the same species. The latter undoubtedly is the Moorea shell. The former, according to the measurements, refers to a larger and more robust shell, being, in fact, the same size and proportion as *P. planilabrum.* In Pfeiffer's original diagnosis he says "læte castaneo bilineata," and, in his Monograph, "læte castaneo trilineata."

The Oahunui shell which was described by Pfeiffer under the name of *strigosa*, is, by some authors, affiliated with *P. nodosa*, an entirely different species, inhabiting a limited area in Tahiti. Mr. Gloyne and Dr. Hartman first pointed out its very close relationship with *P. vexillum* = *lineata*. Indeed, the inosculation is so complete that they must be considered one and the same species.

The Oahunui shells are usually a trifle smaller, not so frequently dentated, and are much more conspicuously strigated than the Vaianai shells. The spiral bands, of which there are one or two, seldom three, on the body-whorl, are very frequently interrupted, which, with the conspicuous strigations, gives the shell a somewhat tessellated appearance. All the color-varieties alluded to in my remarks on the Vaianai shells are also found in Oahunui, but the uniform dark-colored ones are more frequent, besides one of a uniform white color, not decorticated, of which I took three examples.

So far as I can ascertain, there has been no figure published of Pfeiffer's *strigosa*. He gives the Admiralty Islands as its habitat. There are *no* species of the type he describes found in the western Pacific. It is undoubtedly a Society Islands species, and I fully agree with Dr. Hartman in referring it to the shells under consideration. The description is sufficiently near to justify the identification. But I cannot share the above author's views in regard to Pfeiffer's *P. suturalis* being = *strigosa*. There is too much discrepancy in the two diagnoses to warrant their affiliation.

P. LUTEA, Lesson.

Partula lutea, Lesson, Voy. Coquille, p. 325. Pfeiffer, Mon. Hel., iii, p. 453. Pease, Proc. Zool. Soc., 1871, p. 473. (*Ilia*) Hartman, Cat. Part., p. 8 (with woodcut); Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 184, part.

Bulimus luteus, Deshayes, Fer. Moll., ii, p. 123, Pl. CLVIII, figs. 17, 18. Pfeiffer, Mon. Hel., ii, p. 229.

Partula solidula, Schmeltz, Cat. Mus. Godeff., v, p. 92 (not of Reeve).

Partula lilacina, Pfeiffer, Proc. Zool. Soc., 1856, p. 334. Pease, Proc. Zool. Soc., 1871, p. 334.

This, the only species of *Partula* inhabiting Borabora, is peculiar to and widely diffused throughout that island. They occur in larger numbers both on the trunks and foliage of trees and bushes. Notwithstanding its wide range over the island, it has not developed a single local variety. In fact it exhibits less variation than some of the species at the other islands which are restricted to single valleys.

It may be recognized by its rather solid texture, ovate-conical form, rather short spire, large inflated body-whorl, small compressed perforation and white suboval aperture. The parietal region is never toothed. The peristome is white, moderately expanded, not very thick, labiated within, surface rather flat and sloping. Columellar lip subnodose. Color whitish corneous, luteous, fulvous brown, with or without a brown or purple-brown apex. It is never banded. Some are more elongate than others, as the following measurements will show:—

Length 20, diam. $10\frac{1}{2}$ mill.
Length 16, diam. $10\frac{1}{2}$ mill.

A careful comparison of *lutea* with Pfeiffer's description of *lilacina* has convinced me of the correctness of Dr. Hartman's views in uniting the two species. I have no examples of the "lilacina" color mentioned by Pfeiffer. If the determination is correct, his habitat "Marquesas" is certainly wrong.

Reeve's *P. solidula* is decidedly distinct, and of a different type from *lutea*. Reeve's figure closely resembles Pease's *compacta*, but wants the parietal tooth of that species. Pfeiffer describes the peristome as "late expansum, margine dextro superne sinuato, tum strictusculo," which agrees with Reeve's figure, but not with *lutea*.

P. HEBE, Pfeiffer.

Bulimus Hebe, Pfeiffer, Proc. Zool. Soc., 1846, p. 39; Mon. Hel., ii, p. 68. Chemnitz, ed. 2d, Pl. LXIV, figs. 7, 8.

Partula Hebe, Reeve, Conch. Icon., sp. 25, Pl. IV, fig. 25. Pfeiffer, Mon. Hel., iii, p. 453. Pease, Proc. Zool. Soc., 1871, p. 473. Paetel, Cat. Conch., p. 104. Schmeltz, Cat. Mus. Godeff., v, p. 92. (*Œnone*) Hartman, Cat. Part., p. 9 (with woodcut); Obs. Gen. Part., Bul. Mus. Com. Zool., ix, pp. 183, 193.

Partula globosa, Pease, MS. (Mus. Pease, 1863). Gloyne, Quar. Jour. Conch., i, p. 338. Schmeltz, Cat. Mus. Godeff., v, p. 207.
Partula ventricosa, Garrett, MS.
Partula Hebe, var. *bella*, Pease, Proc. Zool. Soc., 1871, p. 473.

The specific centre of the type of this small white species is in the large valley of Faaloa, on the eastern coast of Raiatea, where it is found in great profusion on the foliage of bushes. From this central point it has migrated to the northward, where it is found, though less abundant, in an adjacent valley, associated with the typical *P. dentifera.* About two miles to the southward, on the same side of the island, in a large valley called Opoa, is found in large numbers the pretty variety *bella* (= *globosa*, Pse.), which has passed over a range of wooded hills into a large valley on the south coast, where it occurs in limited numbers in company with *P. formosa.* In another valley, some distance to the northward, on the west coast, we find another variety (= *P. ventricosa*, Garr.), which, though shaped like the type, in color closely resembles *P. crassilabris*, a ground species.

The type, which is *always* decorticated, may be readily distinguished by its ovate-globose shape, uniform white color, not shining, constant prominent parietal tooth and subcircular aperture. Associated with the type are two varieties; one, pinky white, is very rare; the other, white with an orange-colored spire, is rather rare. The variety *bella*, Pse., differs none from the type, except in having the spire more or less light red and the body-whorl most generally with a very thin, smooth, pale yellowish horn-colored epidermis. The variety *ventricosa*, Garr., is usually a little smaller than the type, not decorticated, and is more variable in color, but never banded. The ground color varies from whitish to fulvous, rarely with a reddish spire, but more frequently with the apex of a purple-brown hue.

P. IMPERFORATA, Pease, MS. Plate III, fig. 53.

Partula imperforata, Pease, MS. Coll. Pease, 1863. Paetal, Cat. Conch., p. 104. Pfeiffer, Mon. Hel., viii, p. 209. (*Astræa*) Hartman, Cat. Part., p. 8; Obs. Gen. Part., Bul. Mus. Com. Zool., ix., pp. 183, 195 (part).
Partula dentifera, Carpenter (not of Pfeiffer), Proc. Zool. Soc., 1864, p. 675. Hartman, Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 186 (part).
Partula recta, Pease, MS. (not *recta*, Pease, in Amer. Jour. Conch, 1868) Coll. Pease, 1863.
Partula auriculata, var., Carpenter, Proc. Zool. Soc., 1864, p. 675.
Partula Raiatensis, Garrett, MS.

Shell imperforated or compressly umbilicated, solid, oblong-conic, somewhat shining, with rather smooth, irregular, incremental striæ and closely set delicate spiral incised lines, which are more or less evanescent on the body-whorl; color, pale straw-yellow, luteous, or fulvous, with or without a rosy apex; spire conical, with subplanulate outlines, about half the length of the shell; suture sometimes margined by a rugose white line; whorls 5–5½, flatly convex, the last one convex or convexly rounded; base imperforate, rimate or compressly umbilicated; aperture subvertical, oblong, obauriform, white, sides nearly parallel; parietal wall with a more or less well-developed tubercular tooth; peristome white, thick, moderately expanded, surface concave, heavily labiated within, strongly contracted above, forming a rather profound sinus, and generally subdentate next to the emargination; columellar lip subnodose.

Length 21, diam. 12 mill.

Var. *a*. Uniform chestnut-brown. Rare.

Var. *b*. Base and sutural band chestnut-brown. Somewhat rare.

Var. *c*. With a broad, median, chestnut-brown band. Rather rare.

This species is restricted to Toloa and Hapai valleys on the west coast of Raiatea, where it is abundant on foliage.

Like all the species, they differ some in size, shape, and some have the spire more abbreviated than others. The type which inhabits Hapai valley is nearly always imperforated and may be distinguished from the imperforate *formosa* by its smaller size, gibbous columella and parietal tooth. Carpenter confused it with *dentifera*, an allied species, confined to the opposite side of the island.

P. Raiatensis = *recta*, Pse., MS., which inhabits Toloa, was by Carpenter referred to *auriculata*, a species of a different type. Dr. Hartman unites it to *dentifera*. After a careful study of about 2000 specimens of the two species, I have annexed the Toloa with the Hapai shell. The only difference between the two is that *Raiatensis* is usually lighter-colored, seldom imperforated, and the apex is much more frequently rose-red. It is, I think, more nearly related to the dentated *virginea*, inhabiting the neighboring island, than to *dentifera*.

The latter species is much more frequently edentate on the parietal wall, the lip thicker, more angulated on the surface, and the labial tooth much larger and more acute. It is never banded, and the apex is *not rose-red*, but is frequently tinged with lemon-yellow.

P. COMPACTA, Pease.

Partula compacta, Pease, Amer. Jour. Conch., 1866, p. 200; 1867, p. 81, Pl. I, fig. 9; Proc. Zool. Soc., 1871, p. 473. Paetel, Cat. Conch., p. 104. Schmeltz, Cat. Mus. Godeff., v, p. 92. Pfeiffer, Mon. Hel., viii, p. 207. (*Nenia*) Hartman, Cat. Part., p. 7; Obs. Gen Part., Bul. Mus. Com. Zool., ix, pp. 181, 192.

Partula auriculata, var., Carpenter, Proc. Zool. Soc., 1864, p. 675.

Partula callifera, Gloyne (not of Pfeiffer), Quar. Jour. Conch., i, p. 338.

The metropolis of this common, solid, arboreal species is in Hamoa valley, on the east coast of Raiatea, the home of *P. callifera*. It is confined to the lower half of the valley and has not spread any to the southward, but to the north it is found in limited numbers in two small valleys.

Its principal features are its ovate-conic form, constant parietal tooth, subauriculate aperture, which is much contracted by a thick deposit of callus in the inner margin of the lip, which latter is very broad, flattened and conspicuously sinuous above. The columella is more or less gibbous. Color yellowish corneous, very rarely fulvous or fasciated.

Had Reeve alluded to a parietal tooth in his description and figure of *P. solidula*, I would not have hesitated to refer *compacta* to that species.

P. CLARA, Pease. Plate III, fig. 75.

Partula clara, Pease, Proc. Zool. Soc., 1864, p. 671; 1871, p. 473. Pfeiffer, Mon. Hel., vi, p. 159. (*Pasithea*) Hartman, Cat. Partula, p. 11; Obs. Gen. Partula, Bul. Mus. Com. Zool., p. 181, vol. ix.

A rare species, found on foliage in the upper portions of the valleys in the southwest part of Tahiti. Like *P. annectens*, of Huaheine, and *P. turgida*, of Raiatea, it is gradually becoming extinct.

It is a small species (16 mill.), corneous, sometimes with darker stripes, and more rarely with one or two transverse chestnut bands. The aperture is always edentate.

P. GARRETTII, Pease. Plate III, fig. 48.

Partula Garrettii, Pease, Proc. Zool. Soc., 1864, p. 672; 1871, p. 473. Pfeiffer, Mon. Hel., vi, p. 158. Schmeltz, Cat. Mus. Godeff., v, p. 207. (*Helena*) Hartman, Cat. Part., p. 10; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 182.

Partula gonocheila, Schmeltz (not of Pfeiffer), Cat. Mus. Godeff., v, p. 92.

The specific centre of this small and well-marked species is Vaioara, on the west coast of Raiatea, where it exists in prodigious numbers on bushes. It has spread north and south of its metropolis, and in the former direction has slightly overlapped the southern range of *P. Thalia*, and hybrids between the two species are quite common. To the southward it ranges about one mile, where it extends a short distance up a valley which is the home of *P. citrina*.

Its principal characters are its small size, contracted aperture, rounded or angulated peristome and nodulous columella, which latter is, as it were, pushed in towards the aperture. The parietal region is very rarely toothed. It is whitish or pale yellowish horn-color, rarely fulvous or light brown, and sometimes the apex is purple-brown. A variety with a brown base and sutural band is not infrequent.

P. TURGIDA, Pease. Plate III, fig. 74.

Bulimus turgidus, Pease, Proc. Zool. Soc., 1864, p. 670; 1871, 473. Pfeiffer, Mon. Hel., vi, p. 12.

Partula turgida (*Echo*), Hartman, Cat. Part., p. 12; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 188.

Though widely diffused over Raiatea, it is nevertheless excessively rare. It is much larger, stouter and darker-colored than *P. arguta*, the nearest allied species.

Like *P. clara* and *P. annectens*, it appears to be gradually becoming extinct.

It *does not* inhabit "Tahiti," as stated by Pease.

P. FABA, Martyn. Plate III, figs. 78, 79, 80, Vars.

Limax faba, Martyn, figs., etc., Pl. LXVII. Chenu, Bibl. Conch., ii, p. 24, Pl. XXIV, fig. 2 *a*.

Auris Midæ fasciata, Chem., ix, p. 44, Pl. CXXI, fig. 1041.

Helix faba, Gmelin, p. 3625. Dillwyn, Desc. Cat. Shells, ii, p. 906. Wood, Ind. Test., Pl. XXXIII, fig. 47. Enc. Brit., vi, p. 449, ed. 1817.

Voluta auris Malchi, var., Gmelin, p. 3437.

Voluta fasciata, Dillwyn, Desc. Cat. Shells, i, p. 502.

Bulimus faba, Lamarck, Anim. sans Vert. (Desh. ed.), p. 284. Pfeiffer, Mon. Hel., ii, p. 73.

Bulimus Australis, Bruguière, Enc. Meth., i, p. 347.

Partula australis, Ferussac, Pro. p. 66. Chenu, Lec. Conch., p. 241, fig. 899. Jay, Cat. Shells, p. 57.

Partula faba, Sowerby, Zool. Beech. Voy., p. 144, Pl. XXXVIII, fig, 4. Reeve, Conch. Syst., ii, p. 175, figs. 13, 14. Pfeiffer, Mon. Hel., iii, p 446. Reeve, Conch. Icon., Pl. 1, figs. 5 *a*, *b*, *c*. Woodward, Man. Moll., p. 164, Pl. XII, fig. 13. Chenu, Man. Conch., i, p. 434, fig. 3195. Adams, Gen. Moll., ii, p. 145, Pl. LXXV, fig. 2 *a*. Pease, Jour. de Conch., 1870, p. 400; Proc. Zool. Soc., 1871, pp. 458, 473. Paetel, Cat. Conch., p. 404. Schmeltz, Cat. Mus. Godeff., v, p. 92. Hartman, Cat. Part., p. 6 (with woodcut); Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 182. Excl. *citrina*.

Partulus australis, Beck, Ind. Moll., p. 37.

Bulimus inconstans, Muhlfeldt (teste Anton, p. 40).

Bulimus tricolor, Muhlfeldt (teste Anton).

Partula faba, var. *subangulata*, Pease, Jour. de Conch., 1870, p. 401; Proc. Zool. Soc., 1871, pp. 458, 473 (Pl. III, fig. 79).

Partula ventricosa, Pease, MS. Coll. Pease, 1863.

Partula amanda, Garrett, MS., Pl. III, fig. 78.

Partula dubia, Garrett, MS., Pl. III, fig. 80.

Partula bella, Pease, MS. (*not bella*, Pease, in Proc. Zool. Soc., 1871, p. 473.) Ex. Hartman.

Partula brunnea, Pease, MS. Ex. Hartman.

Partula pallida, Pease, MS. Ex. Hartman.

Partula marginata, Garrett, MS.

Partula biangulata, Pease, MS. Ex. Hartman.

Partula propinqua, Pease, MS. Ex. Hartman.

The metropolis of the well-known typical *faba* is Utuloa, on the north end of Raiatea, the specific centre of *P. auriculata*. It is very abundant on the trunks and foliage of trees and bushes. From its headquarters it has migrated throughout all parts of the island, and notwithstanding its wide diffusion it presents the same features in every location.

It was first obtained when Capt. Cook visited Raiatea in 1769, and first figured by Martyn in his unique "Universal Conchologist."

The type varies from straw-yellow to brownish yellow or fulvous, with a broad basal and narrow sutural chestnut-brown band. The most common bandless variety is of the normal color varied with longitudinal darker strigations. A variety of a uniform, whitish horn-color, as well as one of a uniform chestnut-brown, sometimes approaching black, is not infrequent. The lip is white, and the apex frequently tinted with purple-black.

They vary considerably in shape, as the following measurements will prove:—

Length 25, diam. 14 mill.
Length 25, diam. 12 mill.

The average dimension is 25 by 13 mill. Out of about 6000 examples I found but one possessing the parietal tooth. Hybrids between this species and *radiata*, *fusca* and *navigatoria* are not uncommon.

On the south end of Tahaa, an island inclosed in the same reef which encircles Raiatea, is the headquarters of Pease's var. *subangulata* (Pl. III, fig. 79), which has spread throughout several valleys.

As compared with *faba*, it is smoother, more glossy, thinner, and exhibits different color-variations. The type is reddish brown, with a yellowish sutural band, and the peristome is purple-brown, frequently spotted with white. A variety with a narrow subsutural and subbasal band of a dark chestnut-color on a pale greenish yellow ground is not uncommon. Uniform reddish chestnut and pale greenish yellow varieties with white lips are frequent. Like the typical *faba*, it is frequently strigated and edentate on the wall of the aperture.

The specific centre of the var. *amanda* = *ventricosa* (Pl. III, fig. 78) is on the northeast portion of Tahaa, where it occurs in the greatest profusion, and has migrated throughout all parts of the island, except that portion inhabited by var. *subangulata*.

In shape it differs none from the latter form, but is frequently dentated on the parietal wall, and in some valleys on the north coast, the latter character is constant and = *dubia*, Garr. (Pl. III, fig. 80). The usual color is pale yellowish corneous, light or dark fulvous, with a white or flesh-tinted lip. A beautiful variety occurs which has a wide, median, reddish chestnut band. A more common variety is found with two narrow, reddish chestnut bands. Chestnut-brown varieties are not uncommon. The rarest variety is fasciated the same as the typical *faba*.

P. AURICULATA, Broderip.

Partula auriculata, Broderip, Proc. Zool. Soc., 1832, p. 33. Muller, Syn. Test., p. 33. Reeve, Conch. Syst., ii, p. 175, figs. 7, 8. Jay, Cat. Shells (1832), p. 57. Carpenter, Proc. Zool. Soc., 1864, p. 675 (part). Paetal, Cat. Conch., p. 104. Pease, Amer. Jour. Conch., 1866, p. 20. Schmeltz, Cat. Mus. Godeff., iv, p. 71. (*Nenia*) Hartman, Cat. Part., p. 7, with woodcut; Obs. Gen. Part., Bul. Mus. Com. Zool. ix, pp. 180, 186, 192.
Partula tabulana, Anton, Verz. Conch., p. 40.
Partulus auriculatus, Beck, Ind. Moll., p. 58.
Bulimus auriculatus, Pfeiffer, Symb., i, p. 80; ii, p. 111.
Bulimus Otaheitanus, Pfeiffer, Mon. Hel., ii, p. 71 (part).
Partula Otaheitana, Reeve (not of Bruguière), Conch. Icon., Pl. II, fig. 11 *a*, *b*.
Partula robusta, Pease, MS. Coll. Pease, 1863.

Partula Tahitana, Schmeltz (not of Gould), Cat. Mus. Godeff., v, p. 92. Paetal, Cat. Conch., p. 104. Pease, Proc. Zool. Soc., 1871, p. 473.
Partula maura, Muhlfeldt (teste Anton).

This well-defined arboreal species is restricted to Utuloa, on the north end of Raiatea, where it exists in great profusion, associated with the typical *P. faba*.

In referring to the synonymy and references, it will be observed that this well-characterized species has been frequently confounded with the widely different *P. Otaheitana*, a Tahitian species.

It is accurately figured by Reeve, in his monograph of *Partula*, on Plate II, figs. 11 *a* and 11 *b*. His fig. 11 *c* is *P. crassilabris*, Pease.

In all probability Mr. Reeve had access to Broderip's type specimens, so there cannot be much, if any, doubt of this being the shell the latter had before him when he wrote his description. He may have, as the late Mr. Pease suggested, included more than one species in his diagnosis. His habitat is certainly wrong. The shells were collected by Cuming at Raiatea, not "Huaheine," and, as was too frequently the case, he had forgotten the exact locality.

So far as I can ascertain, there has been no description published, except the brief diagnosis of Broderip. It may be characterized as follows:—

Shell narrowly umbilicated, ovate-conic, scarcely shining, with rather rough incremental striæ, decussated by crowded spiral incised lines, which become evanescent on the last whorl; color varying from whitish to different shades of luteous horn-color, frequently with longitudinal darker strigations; spire rather short, plano-convexly conical, half the length of the shell; apex somewhat obtuse and frequently tinted purple-brown; suture impressed; whorls five, slightly convex, the last one more or less turgid; aperture rather small, subvertical, obauriform, much contracted by the labiated peristome; parietal wall with or without a white tubercular tooth; peristome thick, moderately expanded, white, frequently margined with light brown, contracted above, and the extremities frequently united by a ridge of callus.

Length 18, diam. 12 mill.

The above are about the average dimensions, though they vary some in the relative proportions of height to diameter. Examples of a light brown, or deep blackish brown, or the latter color with a median yellowish band on the body-whorl, are not infrequent.

Dr. Hartman inadvertently cites "Tahiti" as its habitat, and in his chart correctly assigns it to Raiatea.

P. Mooreana, Hartman. Plate III, fig. 55.

Partula Mooreana, Hartman, Proc. Acad. Nat. Sci. Phila., 1880, p. 229; (*Helena*) Cat. Part., p. 10; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p 184.

This arboreal species is abundant, and restricted to Vaianai valley, on the southeast coast of Moorea, where it shares the metropolis of *P. vexillum*, Pse.

It may be characterized by its elongate-ovate form, rather thin texture, constant parietal tooth, planulate-conical spire, which equals half the length of the shell, pale luteous color, with darker apex. It is *always* sinistral, and the white expanded lip is rather thin and moderately incrassated.

A variety with three narrow pale brown revolving bands is not infrequent.

It is closely related to some of the sinistral forms or varieties of *P. Otaheitana*, particularly with Pease's *P. crassa*, which, though of the same shape, is more solid, rougher, and the fine crowded spiral incised lines which extend over the whole surface of the former are nearly obsolete on the latter.

P. FORMOSA, Pease, MS. Plate III, fig. 49.

Partula formosa, Pease (Mus. Pease). (*Astræa*) Hartman, Cat. Part., p. 8; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, pp. 182, 191.

The metropolis of this very distinct species is in Fatimu, or on the southwest part of Raiatea. It occurs in vast numbers on bushes on the lowlands near the seashore, becoming more scarce inland, where it is found associated with *P. Hebe*, var. *bella*. It ranges north as far as Vaiau valley, becoming less and less abundant as the distance increases from its specific centre. It may be characterized as follows:—

Shell large, imperforated, solid, elongate-ovate, striated, shining, pale yellowish white, straw-yellow or fulvous; spire conical, with nearly flat outlines, spirally striated with fine, crowded, incised lines, half the length of the shell, and frequently tinged with rose-red; suture slightly impressed, margined with a rugose, white line; whorls five and a half, flattened, the last one large, convex; aperture oblong, subvertical, obauriform; peristome white, rather widely expanded, declivous, external margin angularly ridged, inner margin strongly labiated, acutely dentate, and contracted above the denticle; parietal region thinly glazed, edentate; columellar lip closely appressed over the umbilical region.

Length 25, diam. 13 mill.

Its large size, edentate parietal region, sharp labial tooth and closed umbilicus will readily distinguish it. It is never ornamented with bands.

P. CALLIFERA, Pfeiffer. Plate III, fig. 82.

Partula callifera, Pfeiffer, Proc. Zool. Soc., 1856, p. 333; Mon. Hel., iv, p. 511. Carpenter, Proc. Zool. Soc., 1864, p. 675. Pease, Proc. Zool. Soc., 1871, p. 473. (*Astræa*) Hartman, Cat. Part., p. 8; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 180.

Partula megastoma, Pease, MS. Schmeltz, Cat. Mus. Godeff., v, p. 92.

Partula callistoma, Schmeltz, l. c., p. 207; vi, p. 81.

A well-characterized species, restricted to the higher portion of Haamoa valley, on the east coast of Raiatea, where it is not uncommon on foliage.

It may be easily determined by its creamy white color, yellow apex, constant parietal tooth, inflated body-whorl, oval or rounded "key-hole" aperture, conspicuous labial tooth and the total absence of epidermis in the adult shells. It is never banded.

P. UMBILICATA, Pease.

Partula umbilicata, Pease, Amer. Jour. Conch., 1866, p. 200; 1867, p. 81, Pl. I, fig. 7; Proc. Zool. Soc., 1871, p. 474. Paetel, Cat. Conch., p. 104. Binney, Proc. Acad. Nat. Sci. Phil., 1875, pp. 245, 247, Pl. XIX, fig. 7 (anatomy). Schmeltz, Cat. Mus. Godeff., iv, p. 71. Pfeiffer, Mon. Hel., viii, p. 207. (*Clytia*) Hartman, Cat. Part., p. 8 (with woodcut); Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 188.

Partula auriculata, var., Carpenter, Proc. Zool. Soc., 1864, p. 675.

The metropolis of this well-defined species is in a large valley, called Haamene, on the east coast of Tahaa, where they are found in prodigious numbers on the foliage of low bushes. It has not spread any to the southward, but, on the other hand, ranges in considerable numbers through all the valleys, except Faa-apa, the home of *bilineata*, as far as Murifanna on the northwest coast, where it is found associated with *P. virginea*.

Its globose-conic form, large umbilicus, constant parietal tooth, rather narrow, slanting lip, subnodose columella and yellowish or brownish horn-color will readily distinguish it.

Var. *a*. Uniform chestnut-brown. Common

Var. *b*. With one or two chestnut-brown bands. Rare.

P. VIRGINEA, Pease, MS. Plate III, fig. 54.

Partula virginea, Pease, MS. Coll. Pease, 1863. Binney, Proc. Acad. Nat. Sci. Phil., 1875, pp. 245, 247, Pl. XIX, fig. 8 (anatomy). Schmeltz, Cat. Mus. Godeff., vi, p. 81. (*Astræa*) Hartman, Cat. Part., p. 8; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 189.

Partula solidula, var., Carpenter, Proc. Zool. Soc., 1864, p. 675. Pease, Proc. Zool. Soc., 1871, p. 473.

The specific centre of this species is in Vaipiti valley, on the west coast of Tahaa, where it occurs in the greatest profusion on the foliage of shrubs. It has extended its range to the northward as far as Murifanna on the north coast, which latter is the limit of the western range of *P. umbilicata*.

It may be described as follows:—

Shell compressly umbilicated, solid, oblong-conic, somewhat shining, yellowish corneous or light fulvous brown; spire convexly conical, half the length of the shell; suture margined by a whitish line; whorls 5–5½, slightly convex; aperture subvertical, oblong, obauriform, rounded below and much contracted by the strongly labiated peristome; parietal wall with a white tubercular tooth which is rarely absent; peristome white, sometimes tinged with carnation, widely expanded, subplanulate, slightly contracted above, and the margins frequently nearly united by a ridge of callus; columellar lip vertical, more or less distinctly nodose.

Length 18, diam. 9 mill.

Var. *a*. Uniform chestnut-brown. Not uncommon.

Var. *b*. Yellowish corneous, with a basal and sutural chestnut-brown band. Very rare.

They vary some in size and length of spire. The nearest allied species is *P. planilabrum*, which is larger, differently colored and inhabits a different station. I have found several hybrids between this species and *P. faba*, var. *subangulata*, Pease.

In referring to the synonymy it will be observed that Carpenter and Cuming regarded it as a variety of Reeve's *P. solidula*. Mr. Pease, accepting their views, catalogued it by the latter name in his list of Polynesian land shells (P. Z. S., 1871, p. 473). Both Reeve's and Pfeiffer's description, as well as Reeve's figure, refer to a more robust species than *virginea*. Moreover, neither of the above authors allude to the parietal tooth, which is seldom absent in the latter species. Reeve's figure very nearly coincides with Pease's *P. compacta*, but that species is always dentate. Hybrids between *P. faba*, var., and *virginea*, which are edentate, very closely resemble Reeve's figure of *solidula*.

P. ARGUTA, Pease. Pl. III, fig. 57.

Bulimus argutus, Pease, Proc. Zool. Soc., 1864, p. 670; 1871, p. 473. Pfeiffer, Mon. Hel., vi, p. 46.

Partula arguta, Schmeltz, Cat. Mus. Godeff., v, p. 92. Martens and Langk., Don. Bismark., p. 55, Pl. III, fig. 7. (*Echo*) Hartman, Cat. Part., p. 11 (with woodcut); Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 179.

The metropolis of this very fragile species is in the upper portion of a mountain ravine, on the west coast of Huaheine, where it is rather common on the leaves of low shrubs and ferns. It occurs much more rarely in a neighboring valley south of its specific centre. Mr. Pease's habitat "Tahiti," as given in his list of Polynesian land shells, is decidedly wrong.

Though referred by the above author to the genus *Bulimus*, it is, nevertheless, a true *Partula*. The animal, which is viviparous, has very long, slender, ocular tentacles, long lance-pointed foot, and that portion of the animal occupying the whorls of the translucent shells is beautifully maculated with black and white spots on grayish yellow ground. The shell, which is very uniform in all its specific characters, may be readily distinguished by its very thin pellucid texture, ovate form, abbreviated spire, turgid body-whorl, uniform pale yellowish horn-color, thin, slightly expanded lip and large simple aperture.

P. BILINEATA, Pease.

Partula bilineata, Pease, Amer. Jour. Conch., 1866, p. 201; 1857, p. 81, Pl. I, fig. 10; Proc. Zool. Soc., 1871, p. 473. Binney, Proc. Acad. Nat. Sci. Phila., 1875, pp. 245, 247, Pl. XIX, fig. 10 (anatomy). Pfeiffer, Mon. Hel., viii, p. 195. Gloyne, Quar. Jour Conch., i, p. 338. Schmeltz, Cat. Mus. Godeff., vi, p. 81. (*Clytia*) Hartman, Cat. Part., p. 8; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, pp. 180, 196.

Partula auriculata, Carpenter (not of Broderip), Proc. Zool. Soc., 1864, p. 675.

This beautiful and well-marked species is confined to Faa-apa valley on the east coast of Tahaa, where it occurs in abundance on the trunks of a species of wild banana and at the roots of ferns. Mr. Pease cites "Tahiti" as the habitat of this species, which is an error.

It is readily distinguished by its smooth, glossy surface, ovate-conic form, yellowish horn-color, and two revolving chestnut-brown bands, the upper one narrow and subsutural. The subacute apex is sometimes purple-brown and the suture is margined by a narrow, rugose, whitish line. The constant parietal tooth is prominent and the broad white peristome is slightly emarginate above, strongly labiate within, and widely expanded.

Var. *a*. With a single broad median chestnut-brown band. Not common.

Var. *b*. Chestnut-brown with a yellowish horn-colored sutural band. Very rare.

Var. *c*. Uniform yellowish horn-color. Very rare.

They are all remarkably uniform in shape and size.

As compared with *P. auriculata*, with which it has been confused, it is more glossy, smoother, the lip broader, the umbilicus more open and the fasciation different. It is more nearly connected with *P. planilabrum* and *virginea*.

P. PLANILABRUM, Pease. Plate III, fig. 77.

Partula suturalis, Pease, MS. (not of Pfeiffer).

Partula planilabrum, Pease, Proc. Zool. Soc., 1864, p. 672; 1871, p. 473. Pfeiffer, Mon. Hel., vi, p. 156. Binney, Proc. Acad. Nat. Sci. Phil., 1865, pp. 245, 247. Schmeltz, Cat. Mus. Godeff., vi, p. 81. Hartman, Cat. Part., p. 7; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, pp. 185, 188, 190.

The metropolis of this species is Haamene valley, on the east coast of Tahaa, where it is common, and, though usually lurking beneath decaying vegetation, is sometimes found adhering to the trunks of the wild banana. It is found, though less abundant, in a valley north of its specific centre, but does not occur in the intermediate valley Faa-apa, the home of *bilineata*.

It is larger and more elongated than the latter species, and the surface is not so smooth and shining. The structure of the peristome is similar in the two shells, but the aperture is more elongate. The parietal tooth is constant in adults.

The type is deep chestnut-brown, gradually fading into yellowish corneous towards the sutural line, and the whitish lip is frequently tinged with violet.

Var. *a* Fulvous yellow, with the basal half of the body-whorl, and a revolving subsutural band, deep chestnut-brown. Not infrequent.

Var. *b*. Uniform pale corneous or light fulvous. Rare.

Like the preceding species it is very uniform in all its specific characters. The fasciation of variety *a* resembles the typical markings of *bilineata*.

P. FILOSA, Pfeiffer. Plate III, fig. 81.

Partula filosa, Pfeiffer, Proc. Zool. Soc., 1851, p. 262; Mon. Hel., iii, p. 450. Chemnitz, ed. 2d, Bul., p. 267, Pl. LXIV, figs. 3, 4. (*Helena*) Hartman, Cat. Part., p. 10; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, pp. 182, 183, 196.

Partula lineolata, Pease, Amer. Jour. Conch., 1867, p. 224; Proc. Zool. Soc., 1871, p. 473. Schmeltz, Cat. Mus. Godeff., v, p. 92. Pfeiffer, Mon. Hel., viii, p. 206.

This small and well-characterized species is restricted to the lower portion of Pirai valley, on the northwest coast of Tahiti, where it is abundant on foliage. Pfeiffer's "habitat in insulis Navigatorum" (= Samoa Isles) is decidedly wrong. The type is peculiar to the Society Isles.

It is a solid, ovate-conic, chestnut-colored shell, marked by longitudinal cinereous strigations, and constant tuberculiform parietal tooth. The aperture is rather small, semi-oval, considerably contracted by the white, convex outer lip. It is never encircled by bands. Examples of a pale straw or flesh tint are not infrequent.

P. CITRINA, Pease. Plate III, fig. 52.

Partula citrina, Pease, Amer. Jour. Conch., 1866, p. 195; Proc. Zool. Soc., 1871, p. 473. Schmeltz, Cat. Mus. Godeff., vi, p. 81. Pfeiffer, Mon. Hel., viii, p. 200.

Partula faba, var., Carpenter, Proc. Zool. Soc., 1864, p. 675. Hartman, Cat. Part., p. 6; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, pp. 180, 195.

This fine arboreal species is restricted to a single valley, called Uparu, on the west coast of Raiatea. I found it abundant in a limited area in the upper portion of the valley. A few stragglers occurred lower down in company with *faba* and *Garrettii.*

Though considered by some authors to be a variety of *P. faba*, I am, nevertheless, fully convinced of its specific value. When I first discovered it in 1861, I took but few examples, in consequence of not penetrating far enough into the valley to find its headquarters. A more extended research in 1873 revealed its specific centre, and I took about eight hundred specimens in various stages of growth, and many of the adults were in a gravid condition.

All of my first collection passed into Mr. Pease's possession, and were so few that I labeled them "a somewhat rare species." There is not the least doubt that the more slender pale varieties of *faba* have repeatedly been confounded with and distributed under the name of *citrina.*

It has been suggested that it may be a hybrid between *faba* and some other species. I only noticed *faba* and *Garrettii* in the lower part of the valley, and *not* in the upper portion, which is the principal haunt of *citrina.*

My largest examples are 25 mill. in length and 12 in diameter. It is *always* of a straw-yellow color, rarely with faint longitudinal darker strigations, and is either lemon-yellow or light red at the apex. It is *never* spirally banded, and the parietal wall is invariably edentate. The oblong white aperture is, including the peristome, half the length of the shell. The ivory-white lip is broadly expanded, planulate, declivous, strongly labiated, slightly dentate and distinctly emarginate above. The slightly gibbous columella is reflected over the small compressed perforation.

Its uniform straw-yellow color, more slender form, smaller perforation, more reflected columella, and more decided labial tooth, and profounder emargination, will distinguish it from the very variable *faba*.

P. NODOSA, Pfeiffer.

Partula nodosa, Pfeiffer, Proc. Zool. Soc., 1851, p. 262; Mon. Hel., iii, p. 449. Pease, Proc. Zool. Soc., 1871, p. 473. Paetel, Cat. Conch., p. 104. Schmeltz, Cat. Mus. Godeff., v, p. 92. (*Helena*) Hartman, Cat. Part., p. 10; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, pp. 184, 188, 195.

Partula trilineata, Pease, Amer. Jour. Conch., 1866, p. 195; 1867, p. 81, Pl. I, fig. 1.

Partula nodosa, var. *trilineata*, Pease, Proc. Zool. Soc., 1871, p. 473.

This beautiful arboreal species is restricted to a limited area about two miles up Punaavia valley on the west coast of Tahiti.

I first discovered the location in 1861, and gathered about three hundred examples. On a subsequent visit, nine years later, I secured over eight hundred specimens. It is *entirely* confined to the south side of the stream which flows through the valley, and circumscribed in a narrow area about three-fourths of a mile in length.

When Mr. Pease described his *trilineata*, he gave the correct locality; but, in his list of Polynesian land shells, he wrongly assigns it to Moorea. Dr. Pfeiffer gives Tahiti and Navigator Islands as its habitat. The type is purely Tahitian, and does not occur at the latter group.

It may be characterized by its ovately conical form, solid texture, constant parietal tooth, nodose columella, and widely expanded white peristome, which is flatly convex, very slightly constricted above and strongly lipped within. The color is creamy white or yellow-corneous, generally with narrow, longitudinal strigations of a brownish color, and ornamented with three revolving, narrow, reddish brown bands. About one in two hundred is sinistral. Bandless varieties are not infrequent, and some are fulvous or light chestnut-brown, with a pale narrow sutural band.

P. HYALINA, Broderip.

Partula hyalina, Broderip, Proc. Zool. Soc., 1832, p. 32. Müller, Syn. Test., p. 32. Reeve, Conch. Syst., ii, Pl. CLXXV, figs. 1, 2. Jay, Cat. Shells (1839), p. 57. Reeve, Conch. Icon., Pl. III, fig. 14. Pfeiffer, Mon. Hel., iii, p. 451. Pease, Proc. Zool. Soc., 1871, p. 473. Paetel, Cat. Conch., p. 104. Schmeltz, Cat. Mus. Godeff., v, p. 92. Garrett, Proc. Acad. Nat. Sci. Phila., 1879, p. 18; Jour. Acad. Nat. Sci. Phila., 1881, p. 396. (*Pasithea*) Hartman, Cat. Part., p. 2; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 183.

Bulinus hyalinus, Sowerby, Conch. Illus., fig. 9.

Bulimus hyalinus, Lam., Ed. Desh., p. 284.

Partulus hyalinus, Beck, Index Moll., p. 57.

This well-known arboreal species has its metropolis or specific centre in the Austral group, some three hundred miles south of Tahiti. It occurs also on Mangaia, one of the Cook's group, about four hundred miles from its metropolis. It is also distributed in limited numbers throughout every valley on Tahiti, but is not found on any other island in the same archipelago. Its extensive range is most remarkable, and it is the only species known to be common to more than one group of islands.

P. PRODUCTA, Pease. Plate III, fig. 51.

Partula producta, Pease, Proc. Zool. Soc., 1864, p. 671; 1871, p. 473. Pfeiffer, Mon. Hel., vi, p. 156. Schmeltz, Cat. Mus. Godeff., v, p, 92. (*Helena*) Hartman, Cat. Partula, p. 10; Obs. Gen. Partula, Bul. Mus. Com. Zool., ix, p. 185.

This species only occurred to my notice in one valley, on the southwest coast of Tahiti, where it is abundant, lurking beneath decaying leaves and under heaps of loose stones.

The type is yellowish fulvous, and invariably marked by three narrow, revolving, reddish brown bands in the body-whorl, and two on the spire. The rather narrow, dull whitish peristome is moderately reflexed, rounded, and the margins united by a layer of callus on the parietal wall, which latter is edentate. It is always dextral, and the rather long spire equals half, or a trifle more than half, the length of the shell.

Var *a*. Body deep chestnut-brown, with or without a pale sutural band, pale base and bilineated spire.

Var. *b*. Uniform pale fulvous or tawny, with a darker apex.

P. ANNECTENS, Pease. Plate III, fig. 70.

Bulimus annectens, Pease, Proc. Zool. Soc., 1864, p. 671. Pfeiffer, Mon. Hel., vi, p. 48.

Partula annectens, Pease, Proc. Zool. Soc., 1871, p. 473. (*Echo*) Hartman, Cat. Part., p. 12; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 179.

This delicate arboreal species is excessively rare, and has only occurred to my notice in two valleys on the west coast of Huaheine.

It is more fragile and more robust than *P. attenuata*, the nearest allied form. The spire is less than half the length of the shell, and the suture is margined by a white line. The dull whitish peristome is widely expanded. The aperture is never dentate, and the yellow-corneous shell is faintly tinged with greenish.

The animal varies from pale luteous-yellow to light brownish yellow. The soft parts, as seen through the transparent shell, are mottled with slate-colored spots. The foot is about the same length as the shell, and the ocular peduncles are very long and slender.

P. CRASSILABRIS, Pease.

Partula crassilabris, Pease, Amer. Jour. Conch., 1866, p. 199; 1871, p. 81, Pl. I, fig. 6; Proc. Zool. Soc., 1871, p. 473. Schmeltz, Cat. Mus. Godeff., v, p. 207. Pfeiffer, Mon. Hel., viii, p. 208. (*Œnone*) Hartman, Cat. Part., p. 9; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, pp. 181, 192 (excl. *rustica*).

Partula Otaheitana, Reeve, Conch. Icon., Pl. II, fig. 11 *c*, not of Bruguière.

Partula Hebe, var., Carpenter, Proc. Zool. Soc., 1864, p. 675.

The metropolis of this small species is in Hapai valley, on the west coast of

Raiatea, the home of *P. imperforata* and *lugubris*. It is very abundant, lurking beneath decaying vegetation and found associated with the typical form of *P. lugubris*. It has not spread any to the northward, but to the southward it has migrated into two small ravines.

It is shaped very much like *Hebe*, but is smaller, the lip less expanded and the body-whorl not so much inflated. The parietal tooth, which is not constant, is not so prominent as in that species. The color varies from pale horn-color to deep brown or reddish brown, with or without a purple-black apex. The peristome is more rounded, and not so pure a white as in *Hebe*.

A variety with a median yellowish band is not uncommon, which Mr. Pease described as the type. Of the two figures quoted in the synonymy and references, Mr. Reeve's is the most characteristic; that of Mr. Pease is too much elongated.

P. ROSEA, Broderip.

Partula rosea, Broderip, Proc. Zool. Soc., 1832, p. 125. Müller, Syn., p. 32. Reeve, Conch. Syst., ii, Pl. CLXXV, figs. 9, 10; Conch. Icon., Pl. I, figs. 1 *a*, *b*, *c*. Jay, Cat. Shells, p. 57 (1832). Pfeiffer, Mon. Hel., iii, p. 448. Pease, Proc. Zool. Soc., 1871, p. 473. Paetel, Cat. Conch., p. 104. Schmeltz, Cat. Mus. Godeff., v, p. 92. (*Matata*) Hartman, Cat. Part., p. 14 (with woodcut); Obs. Gen. Part., Bul. Mus. Com. Zool., ix, pp. 186, 191 (excl. *simplaria*).

Partulus roseus, Beck, Ind. Moll., p. 57.

Bulimus roseus, Pfeiffer, Mon. Hel., ii, p. 70, part.

Partula purpurascens, Pfeiffer, Proc. Zool. Soc., 1856, p. 333; Mon. Hel., iv, p. 511.

Partula cognata, Pease, MS. Coll. Pease, 1863. Schmeltz, Cat. Mus. Godeff., v, p. 92. Gloyne, Quar. Jour. Conch., i, p. 338.

The headquarters of this beautiful and well-known arboreal species is in a large forest at the head of Hawai bay on the west side of Huaheine. From this region, where they are very numerons, they have spread over many parts of the island. They differ but little in shape in the different localities, except in Faahiti on the north coast, where they are smaller, less angulated on the last whorl, and in the total absence of the uniform dark purple-brown and rose-colored varieties which are so common elsewhere. It is the *P. cognata*, Pease. The most numerous variety of the latter form is straw-yellow with the sutural line tinted with rose or purple-rose. A rose or purple-brown variety with a central yellow band is found in no other part of the island.

P. rosea exhibits the following color-variations:

Var. *a*. Uniform yellowish. Very numerous.

Var. *b*. Uniform dark purple-brown. Common. = *P. purpurascens*.

Var. *c*. Uniform rose or rose-red. Common. Type.

Var. *d*. Yellowish, with the base and narrow sutural band purple-brown or rose-color. Common.

Var. *e*. Rose or purple-brown, with the basal half of the body-whorl yellowish. Frequent in the metropolis, but very rare elsewhere.

Var. *f.* Yellowish, with the sutural line tinted with rose or purple-brown. Very common in Faahiti valley, but rare elsewhere. = *P. cognata.*

Var. *g.* Yellowish, with the spire more or less rose or purple-brown. Common.

They vary in a greater or less degree in the proportion of length to diameter, as well as in the thickness of the shell; and some are more distinctly angulated than others.

P. DENTIFERA, Pfeiffer. Plate III, fig. 84.

Partula dentifera, Pfeiffer, Proc. Zool. Soc., 1852, p. 85; Mon. Hel., iii, p. 447. Carpenter, Proc. Zool. Soc., 1864, p. 675 (part). Pease, Proc. Zool. Soc., 1871, p. 473. Schmeltz, Cat. Mus. Godeff., v, p. 207. (*Astræa*) Hartman, Cat. Part., p. 8, with woodcut; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, pp. 181, 183, 194 (excl. *Raiatensis*).

Partula decorticata, Pease, MS. Coll. Pease, 1863.

Partula labiata, Pease, MS. Coll. Pease, 1863. Paetal, Cat Conch., p. 104. Schmeltz, Cat. Mus. Godeff., v, pp. 92, 207. Pfeiffer, Mon. Hel., viii, p. 209.

The specific centre of the type of this species is in the large valley of Vairahi, on the east coast of Raiatea, where it occurs in vast numbers on foliage in company with the typical *P. Hebe.* It has not spread at all to the southward, but, on the other hand, has migrated into a small adjacent valley, where it is much less abundant, and differs from the type in about half of the specimens having a prominent parietal tooth, which is *always* absent in examples inhabiting Vairahi; otherwise the shells are not dissimilar.

It may be distinguished by its elongate-conical form, straw-yellow color, rather shining surface, chink-like perforation, and small oblong obauriform white aperture. The peristome is ivory-white, heavily calloused, the surface angularly ridged, strongly labiated within and armed with a median prominent acute denticle, above which the lip is strongly contracted, forming a conspicuous sinus. A very rare variety occurs of a ruddy brown color, purple-black apex, and flesh-colored peristome. Examples with a white sutural line are not infrequent; otherwise it is *never* ornamented with bands. The most perfect specimens *always* have the body-whorl more or less decorticated behind the peristome, which suggested the provisional name *decorticata.*

P. ELONGATA, Pease.

Partula elongata, Pease, Amer. Jour. Conch., 1866, p. 196; 1867, p. 81, Pl. I, fig. 2; Proc. Zool. Soc., 1871, p. 473. Schmeltz, Cat. Mus. Godeff., iv, p. 72. Pfeiffer, Mon. Hel., viii, p. 196.

Partula lineata, Carpenter (not of Lesson), Proc. Zool. Soc., 1864, p. 676.

Partula tæniata, Hartman (not of Mörch), Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 188 (part).

The headquarters of this arboreal species is in Vaianai valley on the southeast coast of Moorea, where it is abundant, associated with *P. lineata* and *P. Mooreana.* It occurs, also, but in less numbers, in a valley to the westward, where it is found in company with *lineata* and *tæniata.* The same valley, which is about two miles from

Vaianai, is the limit of the range of the latter species on that part of the island, and hybrids between it and *elongata* are rather common, the same as between *Garrettii* and *Thalia* at Raiatea. To the eastward of Vaianai it ranges throughout the small valleys for a distance of several miles, as far as Ohaumi, the specific centre of *strigosa.*

I cannot agree with Dr. Hartman in uniting this species with *tæniata.* It is only through hybrids between the two species that the inosculation takes place. Examples taken in any of the valleys *not* inhabited by *tæniata* prove at once its distinction.

The type is elongated, thin, translucent, corneous, straw-yellow or pale fulvous, frequently with narrow longitudinal darker stripes, and the rather ample aperture is edentated. The outer lip is thin, simple, moderately expanded. The columella is flat, not nodulous or gibbous. Examples with two to four narrow, light chestnut-brown, more or less broken, revolving bands are not infrequent. They vary in the length of the spire, as the following measurements will show:—

Length 17, diam. 7½ mill.
Length 15, diam. 8 mill.

P. THALIA, Garrett. Plate III, fig. 46.

Partula abbreviata, Pease, MS. (not of Mousson) Coll. Pease, 1863.
Partula auriculata, var., Carpenter, Proc. Zool. Soc., 1864, p. 675.
Partula Peaseana. Garrett, MS. (not Peasei, Cox).
Partula Thalia, Garrett, MS. (*Nenia*) Hartman, Cat. Part., p. 7; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, pp. 188, 191, 192.

Shell compressly perforated, solid, ovate-conic, somewhat shining, lines of growth rather smooth, and revolving incised lines very fine and crowded; whitish or yellowish horn-color, with or without a purple-black apex; spire rather short, conical, with plano-convex outlines, half the length of the shell; suture slightly impressed; whorls five, flatly convex, the last one large, subglobose; aperture subvertical, abbreviately subauriform; parietal region more or less glazed, and armed with a white tubercular tooth; peristome white, moderately expanded, thick, angularly ridged, strongly incrassated within, sinuous above, and the margins frequently joined by a ridge of callus.

Length 17, diam. 11 mill.

Var. *a.* Fulvous brown, with or without purple-black apex. Rather rare.

Var. *b.* With brown base and sutural band. Not common.

The specific centre of this very abundant arboreal species is in Huaru valley, on the west coast of Raiatea. It has spread along the well-wooded lowlands about two miles north and one mile south of its metropolis, slightly overlapping the northern range of *P. Garrettii.*

It is smaller, smoother, more shining, much less variable in color, and the aperture is less auriform than *P. auriculata.*

The columella is frequently slightly gibbous or nodulous in the inner margin.

P. STOLIDA, Pease. Plate III, fig. 58

Partula stolida, Pease, Amer. Jour. Conch., 1866, p. 198; Proc. Zool. Soc., 1871, p. 473. Pfeiffer, Mon. Hel., viii, p. 195. (*Helena*) Hartman, Cat. Part., p. 10; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 187.

Partula Vanikorensis, Carpenter (not of Quoy and Gaimard), Proc. Zool. Soc., 1864, p. 675.

I took a few examples of this ground species about two miles up Papenoo valley, on the northeast coast of Tahiti. They were all found lurking among the roots of ferns. When Mr. Pease described it, he gave the habitat "Tahitian archipelago," and in his list of Polynesian land shells (Proc. Zool. Soc., 1871), he erroneously cites "Raiatea" as its locality.

Unfortunately I have only three examples before me, so I cannot decide on its variation. All my duplicates, which were acquired by Mr. Pease, were very uniform in shape. It may be described as an elongate-ovate, rather thin, dull brownish or olive-brown shell, 18 to 20 mill. in length by 9 to 10½ in diameter. The spire which comprises half the length of the shell is more swollen than in the elongate dextral *P. Otaheitana*. The parietal region is usually toothed, and the peristome is thinner, not so much reflected, more flattened and oblique. No banded examples occurred.

Dr. Hartman gives the wrong locality. The locality is rightly indicated on his chart.

P. ATTENUATA, Pease.

Partula attenuata, Pease, Proc. Zool. Soc., 1864, p. 672; 1871, p. 473. Pfeiffer, Mon. Hel., vi, p. 156. Schmeltz, Cat. Mus. Godeff., v, p. 92. Gloyne, Quar. Jour. Conch., i, p. 337. (*Pasithea*) Hartman, Cat. Part., p. 11; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 179.

Partula gracilis, Pease, Amer. Jour. Conch., 1866, p. 197; 1867, p. 81, Pl. I, fig. 3. Binney, Proc. Acad. Nat. Sci. Phil., 1875, pp. 244, 247, Pl. XIX, fig. 6 (part of jaw). Pease, Proc. Zool. Soc., 1871, p. 473. Paetel, Cat. Conch., p. 104.

Partula amabilis, Carpenter (not of Pfeiffer), Proc. Zool. Soc., 1864, p. 675.

Partula Carteretensis, Reeve (not of Quoy and Gaimard), Conch. Icon., sp. 13, Pl. IV, fig. 13. Schmeltz, Cat. Mus. Godeff., iv, p. 72.

This small species, which has an extensive range, occurs in the upper portions of all the central valleys on both the east and west sides of Raiatea. It is more abundant in Toloa and Hapai valleys than elsewhere. Owing to its peculiar habit of living on the foliage near the tops of trees, it easily escapes observation. It occurs more rarely at Tahiti, where it has, also, a wide range, and, like the Raiatea shells, is confined to the upper portions of the valleys.

When we take into consideration its peculiar habit of concealment in the tops of trees, and its range restricted to the more elevated portions of the valleys, so contrary to the habits of other species, it is really remarkable to find it inhabiting two remote islands, especially as all the other species have a very limited range. It does not occur at Tahaa, which is only four miles from Raiatea, and enclosed in the same encircling reef. It is no less singular to note its absence from Huaheine and Moorea, though at the former island we find the closely allied *P. annectens.*

Its most essential characters are its graceful oblong-conic shape, narrow body-whorl, uniform whitish horn-color and broadly expanded white lip.

Reeve has erroneously described and figured this species under the name of *P.* "*Carteretensis*," Quoy and Gaimard. The latter author's *P. Carteriensis* (*Helix*) is of an entirely different type.

P. FUSCA, Pease. Plate III, fig. 50.

Partula fusca, Pease, Amer. Jour. Conch., 1866, p. 193; Proc. Zool. Soc., 1871, p. 473 Paetel, Cat. Conch., p. 104. Binney, Proc. Acad. Nat. Sci. Phil., 1875, pp. 245, 247, Plate XIX, fig. 9 (anatomy). Pfeiffer, Mon. Hel., viii, p. 205. Schmeltz, Cat. Mus. Godeff., vi, p. 81. Hartman, Cat. Part., p. 6; Obs. Gen. Part., Bul. Mus. Com. Zool., ix. p. 182 (excl. *ovalis* and *lugubris*).

Partula protea, Pease, MS. Coll. Pease, 1863. Schmeltz, Cat. Mus. Godeff., v, p. 92. Pfeiffer, Mon. Hel., viii, p. 209.

Partula faba, var., Carpenter, Proc. Zool. Soc., 1864, p. 675 (= *protea*).

Partula navigatoria, Carpenter, l. c., not of Pfeiffer.

The metropolis of this very variable ground species is in Vaioara valley, on the west coast of Raiatea, the headquarters of *P. Garrettii* and *navigatoria.* It has not migrated any to the southward, but to the northward it occurs sparingly far up in Huaru valley. On the opposite side of the island it is found in Tepua valley, and I took a few in a small ravine more to the southward. The Tepua shell, which is the *protea*, Pse., differs none from his *fusca.*

Hybrids between *protea* and the arboreal *P. faba* are not uncommon, and are usually found adhering to the lower parts of the trunks of trees.

In Vaioara, hybrids between *fusca* and *navigatoria*, and between the two former and *faba*, are so frequent as to be very embarrassing in the separation of the three species collected in that valley. Like the Tepua hybrids, all those between the two ground species and the arboreal *faba* live on the lower parts of the trunks of trees.

P. fusca may be described as follows:—

Shell umbilicated, solid, varying from an abbreviate-ovate to oblong-ovate, roughly striated by irregular lines of growth, and the usual fine spiral incised lines become evanescent on the body-whorl; spire convexly conical, less than half the length of the shell; suture linearly impressed, frequently margined by a thread-like white line; whorls 5–6, more or less flatly convex, last one large, convex, rounded or turgid, sometimes slightly angled just above the aperture; base more openly umbilicated than usual in the ground species; aperture subvertical, oblong, sides nearly parallel; parietal region more or less glazed with callus, and sometimes dentate; peristome rather broadly expanded, moderately thick, slanting, flat or concave, strongly incrassated within and sinuous above; columellar lip depressed, receding or transversely grooved above. Color very variable: whitish corneous, straw-yellow, fulvous, light or dark chestnut, sometimes brown-black, and frequently strigated. Yellowish horn-colored examples with the base and the sutural band chestnut, are not uncommon. The lip, though usually white, is frequently margined with purple-brown.

Length 20, diam. 11 mill.

The above is about the average dimensions. My largest example is 24 by 13½ and the smallest adult 17 by 10 mill. Sometimes, though rarely, the spire equals half the length of the shell. Very old examples have a more or less nodulous columella and a more or less distinct denticle on the outer lip.

P. TÆNIATA, Mörch.

Bulimus (*Partulus*) *tæniatus*, Mörch, Cat. Conch. Kjerulf., p. 29.

Bulimus Otaheitanus, var., Pfeiffer, Mon. Hel., ii, p. 72, part.

Partula tæniata, Pfeiffer, Mon. Hel., iii, p. 451. Carpenter, Proc. Zool. Soc., 1864, p. 675. Hartman, Obs. Gen. Part. Bul., Mus. Com. Zool., ix, p. 188 (part).

Partula striolata, Pease, Amer. Jour. Conch., 1866, p. 197; 1867, p. 81, Pl. I, fig. 4; Proc. Zool. Soc., 1871, p. 473. Pfeiffer, Mon. Hel., viii, p. 203.

Partula simulans, Pease, Amer. Jour. Conch., 1866, p. 202; 1867, p. 81, Pl. I, fig. 11. Paetel, Cat. Conch., p. 104. Schmeltz, Cat. Mus. Godeff., v, p. 92. Pfeiffer, Mon. Hel., viii, p. 206.

Partula nucleola, Pease, MS. Coll. Pease, 1863.

Partula decussatula, Carpenter (not of Pfeiffer), Proc. Zool. Soc., 1864, p. 675.

Partula spadicea, Hartman (Reeve?), Cat. Part., p. 11.

The metropolis of this truly protean species is in a very large semicircular valley on the north coast of Moorea, where it occurs in prodigious numbers on the foliage of bushes. In the western part of the same valley, where it exhibits less variation, it gradually intergrades with the form which has been distributed under the name of *nucleola*, Pease, which has its headquarters in a small, but isolated, valley about two miles west of Opunohu.

Pease's *nucleola*, which is quite abundant, is usually smaller, more solid, spire shorter, aperture smaller and more rounded, and the columella is more distorted, than in the typical *tæniata*. But in looking over a large number of specimens we notice some examples which cannot be separated from some of the smaller forms of the latter species.

On the southwest part of the island we find *tæniata* tolerably abundant in three valleys, and, like the shells in the western part of Opunohu, it is subject to much less variation than obtains in the eastern part of the same valley. The shells from the southwest coast were described by Pease under the name of *P. simulans*.

In the third or more eastern valley, where they come in contact with *P. elongata* and *lineata*, hybrids between the former and *tæniata* are so numerous that any one collecting in that valley only would, without hesitation, pronounce them one and the same species.

From this point to a distance of several miles, the valleys are inhabited by *lineata*, *Mooreana*, *elongata* and *lineata*, var. *strigosa*, only. But after passing Oahumi, the home of the latter variety, we again find *tæniata*, but nearly as variable as the eastern Opunohu shells, and mixed with the form known as *striolata*, Psc., with which it intergrades. Here I found several unmistakable hybrids between *strigosa* and *tæniata*. All the valleys between this latter location and the one nearest to Opunohu are inhabited by the typical form *striolata*, which scarcely differs from *nucleola*, except in being smoother and more variegated with stripes. In a large valley adjacent to Opunohu, we find these shells by thousands; they differ in being beautifully striped like *strigosa*. Here, again, it insensibly graduates into the typical *tæniata*. Whether the inosculation takes place through hybrids or not is a difficult question to decide In looking over a large collection from the eastern part of Opunohu, I find some of the small forms are not dissimilar to the typical *striolata*, which has suggested the propriety of following Dr. Hartman in consolidating the three forms.

The typical *tæniata* varies from abbreviate-ovate to elongate-ovate, more or less solid, scarcely shining, smooth or wrinkled with incremental striæ, and the spiral incised lines are very fine, and crowded on all the whorls. The spire is more or less produced half the length of the shell, sometimes shorter or a trifle longer. Whorls moderately convex, the last one convex or convexly rounded, frequently compressed in the back and right side, which gives it a faint biangular appearance. The subvertical aperture, which is variable in size and shape, varies from subovate to oblong. The peristome is more or less expanded, sometimes considerably so, moderately thick, slanting and labiated within. Columellar lip more or less tortuous, abruptly receding above, which gives it a nodulous appearance. About one in a hundred exhibits the parietal tooth. The following measurements will illustrate the variability in shape:—

Length 17, diam. 9, aperture (including lip) $9\frac{1}{3}$ mill.
Length 17, diam. 8, aperture (including lip) 8 mill.
Length 13, diam. 7, aperture (including lip) 8 mill.

The color is also variable: white, straw-yellow, lemon-yellow, light orange, corneous, fulvous, various shades of brown, sometimes with darker strigations, and frequently spirally banded. The most common style of fasciation consists of from one to four narrow, more or less broken, fulvous or fulvous-brown bands on the body-whorl. Fulvous-brown examples, with two or three pale bands, are not so common. The last appears to be Mörch's type, which he incorrectly assigns to the Viti Islands.

Pease's *striolata* and *nucleola* exhibit the same coloration as the typical *tæniata*, but are sometimes of a deeper brown, and the former is more conspicuously strigated.

Dr. Hartman, on the authority of Pfeiffer, quotes *P. peraffinis*, Pse., which he adds to the synonymy of *tæniata*. I do not know any such species, and cannot find any reference to it in Pfeiffer's Monographs. He also regards Reeve's *spadicea* as identical with *tæniata*. Both Reeve and Pfeiffer quote the Marquesas Islands as the habitat of that species, but Pease and Dr. Cox mention having received it from the Solomon

Islands. Judging from the description and figure of *spadicea*, I am inclined to consider it distinct and an inhabitant of the latter group of islands.

P. RADIATA, Pease, MS. Plate III, fig. 45.

Partula radiata, Pease, MS. Coll. Pease, 1863. Hartman, Cat. Part., p. 7; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 185 (part).

Partula compressa, Carpenter (not of Pfeiffer), Proc. Zool. Soc., 1864, p. 675. Pease, Proc. Zool. Soc., 1871, p. 473. Schmeltz, Cat. Mus. Godeff., v, p. 207.

Partula microstoma, Pease, MS. Coll. Pease, 1863.

Partula vittata, Hartman (not of Pease), Cat. Part., p. 7 (part).

Shell rimately perforated, moderately thick, not shining, surface roughened by unusually coarse, rude incremental striæ, and the spire marked by more or less distinct crowded spiral incised lines; color whitish or pale luteous horn-color, with longitudinal, irregular, narrow darker stripes; spire conical, with planulate outlines, half the length of the shell; apex subacute, concolored, white, or light brown; suture linearly impressed, sometimes whitish; whorls 5–5½, flatly convex, last one large, convex, sometimes obsoletely angulated in front and generally a little compressed behind the outer lip; aperture subvertical, oblong, obauriform, sides parallel; parietal region more or less glazed, and, with few exceptions, furnished with a white tubercular tooth; peristome whitish, frequently margined with pale purplish brown, rather thin, considerably expanded, concave, very obliquely slanting, strongly and acutely labiated on the inner margin, which is more or less distinctly toothed and sinuous above; columellar lip subnodose.

Length 21, major diam. 10 mill.

Var. *a*. Uniform chestnut-brown. Frequent.

Var. *b*. With a chestnut-brown base and sutural band. Not uncommon.

Var. *c*. With a median brown or chestnut-brown band. Somewhat rare.

The metropolis of this species is in Hamoa valley, on the east coast of Raiatea, the home of *callifera* and *compacta*. It is quite common beneath decaying vegetation and among piles of loose stones. It has not spread any to the northward, but occurs in limited numbers in all the valleys south as far as Vairahi, the headquarters of *P. dentifera*.

P. microstoma, which inhabits the latter valley, though very frequently found adhering to the lower portion of the trunks of trees and shrubs, can scarcely be separated from *radiata*, which is strictly terrestrial in habit. Dr. Hartman unites it with *P. vittata*. It appears to me more nearly related to *radiata* than the latter, which is smoother, and the columellar lip is flat and simple.

The Hamoa shell, which has been widely distributed under the name of *compressa*, is considered by Dr. Hartman to be entirely distinct from the latter, and I follow him in restoring Pease's original name. Hybrids between these shells and *P. faba* are not infrequent.

P. VITTATA, Pease. Plate III, fig. 56.

Partula vittata, Pease, Amer. Jour. Conch., 1866, p. 194; Proc. Zool. Soc., 1871, p. 473. Pfeiffer, Mon. Hel., viii, p. 200. Hartman, Cat. Part., p. 7; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 169 (excl. *microstoma*).

Partula terrestris, Pease, MS. Coll. Pease, 1863. Paetel, Cat. Conch., p. 104. Gloyne, Quar. Jour. Conch., i, p. 388.

Partula castanea, Pease, Coll. Pease, 1863.

Partula faba, var., Carpenter, Proc. Zool. Soc., 1864, p. 675.

Partula approximata, Pease, MS. Coll. Pease. Schmeltz, Cat. Mus. Godeff., v, p. 207. Gloyne, Quar. Jour. Conch., i, p. 338. Hartman, Cat. Part., p. 7; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, pp. 179, 195.

The shape of the typical *vittata* is oblong-conic, more or less compressly umbilicated, and the spire, which equals half the length of the shell, has subplanulate outlines. The ample, oblong aperture is considerably contracted by the intrusion of callus on the inner margin of the peristome, and the sides are nearly parallel. The peristome is rather thin, widely expanded and usually stained with brownish purple. The superior inner margin of the lip exhibits a shallow sinus. The columella is flattened, *not* nodose, and reflected over the umbilicus. The color is whitish, yellowish corneous, fulvous or horn-color, frequently with the basal third of the body and sutural band chestnut-color. Sometimes the apex is black or purple-black. The parietal tooth, though small, is constant. My largest examples are 25 mill. long, and 11 in diameter.

The type is restricted to the higher portions of Toloa valley, on the west coast of Raiatea, where it is not uncommon beneath decaying vegetation. It has not spread any to the northward, but, on the other hand, occurs in greater or less profusion, in a modified form (= *approximata*), in several small valleys on the southwest part of the island. No examples were discovered in Hapai or Vaiau, the headquarters of *lugubris* and *ovalis*, which two valleys are between Toloa and the small ones inhabited by *approximata*.

The latter, which may be regarded as a variety of *vittata*, is characterized by its inferior size, smaller umbilicus, which is frequently impervious, smaller aperture, and less expanded lip. The parietal tooth is very seldom developed. The fasciation is similar in the two forms, but occurs rarely in *approximata*. The latter differs, also, in being generally a lighter or darker chestnut-color, though both have similar horn-colored varieties.

In the valleys on the southern part of the island, we find a gradual change from the typical *P. approximata* into the form known as *P. terrestris*, Pease, which latter connects the former with *vittata*. It is of equal size, and exhibits a similar perforation, large aperture and widely expanded lip. The parietal tooth is seldom absent, and in coloration we find the same style of fasciation, but, like in *approximata*, it is less frequent than in *vittata*. It differs from *approximata* in being generally light horn-color, with darker strigations.

The range of *terrestris* terminates at Opoa valley, on the southeast coast. At Faaloa, on the east coast, there exists a form which is the *P. castanea*, Pease, and is intermediate between *terrestris* and *vittata*. It is usually chestnut-colored, constantly toothed on the parietal wall, and the fasciation is the same as in the other varieties. It has not spread any to the northward of Faaloa, but occurs more sparingly in a small valley between Faaloa and Opoa.

P. NAVIGATORIA, Pfeiffer.

> *Bulimus navigatorius* (*Partula*), Pfeiffer, Proc. Zool. Soc., 1849, p. 131.
> *Partula navigatoria*, Reeve, Conch. Icon., Pl. IV, fig. 21. Pfeiffer, Mon. Hel., iii, p. 449. Carpenter, Proc. Zool. Soc., 1864, p. 675. Hartman, Cat. Part., p. 7; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 184.
> *Partula variabilis*, Pease, Amer. Jour. Conch., 1866, p. 203; 1867, p. 81, Pl. 1, figs. 12–14; Proc. Zool. Soc., 1871, p. 473. Paetel, Cat. Conch., p. 104. Schmeltz, Cat. Mus. Godeff., p. 207. Pfeiffer, Mon. Hel., viii, p. 201.

This species has its headquarters in the lower portion of Vaioara valley, on the west coast of Raiatea, where it is very abundant, associated with *P. fusca*. Though usually found lurking beneath decaying vegetation, it is sometimes taken on the trunks of trees. It does not occur in the next valley to the northward, the home of *P. Thalia*, but has spread along the lowland forests south as far as Upara valley. Hybrids between this species and *fusca* and *faba* are very frequent.

Mr. Pease states, in a letter received from him in 1870, that he had determined *navigatoria* to be a small variety of *P. faba*, and in the following year he published his list of Polynesian land shells, and excluded Pfeiffer's species from the *Partula*.

According to the latter author's description, and Reeve's figure, it is undoubtedly the same as Pease's *variabilis*; and, though a misnomer, must, according to the law of priority, take precedence over the latter species.

The parietal tooth mentioned by Pfeiffer, but not alluded to by Reeve or Pease, is not constant, but exists in about two-fifths of the adults. The former author's "medio subdentato," likewise not mentioned by the latter two writers, is simply the lower angle of the small labial sinus.

In shape it varies from ovate to oblong-ovate, as the following two measurements will show:—

Length 25, diam. 13 mill.
Length 20, diam. 13 mill.

Mr. Pease's accurate figures represent the normal or usual form, and his figures 12 and 13 the typical color, which is luteous or yellowish horn-color, with longitudinal strigations. Uniform whitish corneous or chestnut-colored varieties occur, but are not common. A more abundant variety is the usual one of a chestnut-brown base and sutural band.

P. RUSTICA, Pease.

Partula rustica, Pease, Amer. Jour. Conch., 1866, p. 199; 1867, p. 81, Pl. I, fig. 5; Proc. Zool. Soc., 1871, p. 473. Schmeltz, Cat. Mus. Godeff., v, p. 207. Pfeiffer, Mon. Hel., viii, p. 205.
Partula auriculata, Carpenter (not of Broderip), Proc. Zool. Soc., 1864, p. 675.
Partula crassilabris, Gloyne (not of Pease), Quar. Jour. Conch., i, p. 338. Hartman, Cat. Part., p. 9; Obs. Gen. Part., Bull. Mus. Com. Zool., ix, p. 187 (part).
Partula pinguis, Garrett, MS.

The metropolis of this species is in a large valley called Toloa, on the west coast of Raiatea, where it occurs in great abundance beneath decaying vegetation. It has migrated to the southward into two small adjacent valleys, but does not extend its range so far as Hapai, the next large valley, and the home of the allied *P. crassilabris.*

It is larger, less globose, the aperture more oblong, than the latter species, with which it has been confounded. Its chief character consists in the columellar region being, as it were, pressed in towards the aperture, nodulous on the inner margin, and subangulated at the base. The parietal tooth is less developed and more frequently absent than in *crassilabris.* The coloration is the same in the two species. Like the majority of the ground species, it varies in a greater or less degree in shape and size. Some forms almost exactly simulate *P. Garrettii*, not only in the outline of the shell, but in the peculiar shape of the aperture as modified by the columella being pressed inwardly. Occasionally examples occur which are so much abbreviated that they resemble *P. crassilabris*, but may readily be separated by the dissimilarity in the columellar region.

My *P. pinguis*, of which I have seen only a dozen examples, was found under decaying leaves in the mountain ravines, at the head of Vaioara valley. It certainly = *rustica.*

P. LUGUBRIS, Pease. Plate III, fig. 47.

Partula lugubris, Pease, Proc. Zool. Soc., 1864, p. 672; 1871, p. 473. Pfeiffer, Mon. Hel., vi, p. 158. Schmeltz, Cat. Mus. Godeff., v, p. 207.
Partula ovalis, Pease, Amer. Jour. Conch., 1866, p. 194; Proc. Zool. Soc., 1871, p. 473. Pfeiffer, Mon. Hel., viii, p. 205.
Partula dentifera, Carpenter (not of Pfeiffer), Proc. Zool. Soc., 1864, p. 675 (= *ovalis*).
Partula fusca, Hartman (not of Pease), Cat. Part., p. 6; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, p. 182 (part).

The specific centre of this ground species is in Vaiau valley, on the west coast of Raiatea, the northern limits of the range of *P. formosa.* It has not spread any to the southward, but, on the other hand, has migrated to the northward into Hapai valley, the headquarters of *P. crassilabris*, with which it is found associated.

The Hapai shell was first described by Mr. Pease, under the name of *lugubris*, and, although nearly as abundant as the Vaiau form (= *ovalis*, Pse.), is smaller, thinner, more attenuated and more variable in color and fasciation.

However, the difference between the two species is so slight that I think it best to unite the two forms.

In shape they vary from abbreviate-ovate to oblong-ovate, not solid, roughly striated, spire usually half the length of the shell, sometimes shorter, and the base more or less compressly umbilicated. The aperture is rather large, suboval, *edentate*, and the columella is depressed, *not* nodulous. Sometimes the front of the body-whorl is faintly angulated. The outer lip is rather thin, moderately expanded, slanting, concave, more or less stained with purple-brown, sometimes dull whitish or tawny, and the inner margin, which is not very heavily labiated, is in adults slightly sinuous above.

The color varies from light chestnut-brown to dark chestnut, sometimes fulvous. Examples with a more or less broad, median, yellowish corneous band are not infrequent in both the Vaiau and Hapai shells.

The following two varieties occur in the typical *lugubris* only :—

Uniform whitish horn-color, with pure white lip. Rather rare.

Yellowish horn-color, with a median, narrow, reddish chestnut band. Rare.

My largest Vaiau specimens are $20\frac{1}{2}$ mill. long, and 11 mill. in diameter. The smallest adult from Hapai is 16 by 8 mill.

I have found hybrids between *lugubris* and *imperforata*, the latter a strictly arboreal species.

Dr. Hartman, overlooking the fact that *lugubris*, *ovalis*, *protea* and *fusca* inhabit widely separated valleys, has suggested that the three former may be the juvenile and adolescent forms of the adult *fusca*. The habitats of the two former species are about two miles apart, and five miles south of the location of *fusca*. *P. protea*, which = *fusca*, is confined to the opposite side of the island, and is separated from the latter by an almost inaccessible mountain.

I cannot conceive how Carpenter could have referred Pease's *ovalis* to Pfeiffer's *dentifera*, a shell of an entirely different type. He also says, in a foot-note to the former author's diagnosis of *lugubris*: "This species is regarded by Mr. Cuming as probably a variety of *P. pacifica*, Pfr.," which latter is by Dr. Hartman referred to *P. Otaheitana*.

P. VARIA, Broderip.

Partula varia, Broderip, Proc. Zool. Soc., 1832, p. 125. Müller, Syn., p. 33. Reeve, Conch. Syst., ii, Pl. CLXXV, figs. 5, 6; Conch. Icon., Pl. III, figs. 17 *a*, *b*, *c*. Pfeiffer, Mon. Hel., iii, p. 448. Pease, Proc. Zool. Soc., 1871, p. 473, *et* var. *glutinosa*, *pulchra*, *simplex*. Paetel, Cat. Conch., p. 104. Schmeltz, Cat. Mus. Godeff, v, p. 92. (*Matata*) Hartman, Cat. Part., p. 14; Obs. Gen. Part., Bul. Mus. Com. Zool., ix, pp. 189, 191 (excl. *strigata*).

Bulimus varius, Pfeiffer, Symb., i, p. 86; ii, p. 124.

Bulimus roseus, var., Pfeiffer, Mon. Hel., ii, p. 70.

Partula glutinosa, Pfeiffer, Proc. Zool. Soc., 1852, p. 85; Mon. Hel., iii, p. 448. Paetel, Cat. Conch., p. 104.

Partula mucida, Pfeiffer, Proc. Zool. Soc., 1855, p. 98; Mon. Hel., iv, p. 513.

Partula pulchra, Pease, MS. Col. Pease, 1863. Schmeltz, Cat. Mus. Godeff., v, p. 92.

Partula Huaheinensis, Garrett, MS.

Partula bicolor, Garrett, MS.
Partula adusta, Garrett, MS.
Partula lugubris, Gloyne (not of Pease), Quar. Jour. Conch., i, p. 338.
Partula simplaria, Schmeltz (Morelet ?), Cat. Mus. Godeff., v, p. 92.
Partula perplexa, Pease, MS. Coll. Pease. (Ex. Hartman.)

The metropolis of the typical *P. varia* is in two valleys on the west coast of Huaheine, where they are very abundant on foliage. It was first discovered by Mr. Cuming, who gave the habitat "Society Islands," and gratuitously added that of the "Navigator Islands," where it is *not* found.

The type is very variable in coloration, and considerably so in size and shape. The smallest form, which = *P. pulchra*, Pse., gradually merges into the type, and is restricted to the largest of the two valleys called Hamene. The type which equals my *Huaheinensis* and *adusta*, is usually corneous, luteous, more frequently fulvous, rarely white, and the most abundant variety is dark chestnut, sometimes nearly black with a pale apex and dark or pale lip. Deep chestnut-colored examples, with a wide or narrow central pale band, are not uncommon, and are well represented by Reeve's fig. 17 *a*. His fig. 17 *b*, with an obscure central fulvous band on a pale ground, is rather common.

In the higher portion of Hamene may be found a large form = *bicolor*, Garr., which is either uniform straw-yellow, or greenish yellow, with or without a dark chestnut spire. It differs from the typical *varia* in being larger, more robust, the whorls more inflated and the aperture wider.

In a valley named Faahiti, on the northern part of the island, we find in the greatest profusion, associated with *P. cognata*, Pse., a form shaped like *bicolor*, but smaller and more variable in color than the typical *varia*. The most common variety is light yellowish, sometimes strigated, the lip, and sometimes the base, stained with burnt-brown or violet-brown. Nearly half of the specimens are uniform fulvous brown, or chestnut-brown approaching black. The variety with central pale band is also very frequent, as well as the one of a uniform whitish or luteous with white lip. The pale variety with chestnut spire is somewhat rare, besides one with a dark spire and two narrow bands on the body-whorl. A lot of these shells sent to the "Museum Godeffroy," were by Prof. Mousson referred to Morelet's *P. simplaria*, and have been freely distributed under that name. Morelet cites "Tahiti" as the habitat of his species. His "apice obtuso rosaceo" and "sutura albo marginata" do not occur in these shells nor any of the varieties of *varia*. Mr. Pease did not identify it with any of the Huaheine shells; but Dr. Hartman, on the contrary, regards it as a variety of *P. rosea*.

Besides the three valleys just alluded to, we find this species generally distributed in greater or less numbers throughout all parts of the island, but subject to much less variation in form and color. Like *bicolor*, and the generality of the Faahiti shells, they are more robust and the whorls more swollen than the typical *varia*. The most common variety is luteous, or straw-yellow, sometimes pale fulvous with the lip more or less stained with violaceous brown. The variety with a white peristome is not uncommon, and a beautiful variety, with a very dark violaceous black spire and wide band of the same color on the middle of the body-whorl, is much more infrequent, as well as the one with a dark spire, without the band. The dark variety with yellowish band, so common in the type and the Faahiti shells, is rarely found elsewhere. The first mentioned variety, which comprises nearly 75 per cent. of the specimens, is probably Pfeiffer's *P. glutinosa*, which Pease quotes as a variety of *P. varia*. Dr. Hartman, in his Catalogue of Partula, records it as a distinct species, and in Observations on the Genus Partula cites the Navigator and Solomon Islands as its habitats; in the same paper he states, in his remarks on Pease's duplicates, that "*P. glutinosa*, Pfr., in one quart was uniform in size and color," which coincides with the Huaheine shells. Both Pease and Dr. Cox have assured me that they have never received Pfeiffer's *glutinosa* from either the Navigator or Solomon Islands. The shells referred to were collected by me on Huaheine, and, as just mentioned, were by Pease regarded as *P. varia*, var. *glutinosa*. Pfeiffer, who erroneously cites the Solomon Islands as the habitat of the latter, remarks, in his fourth volume, that Reeve's *P. varia*, fig. 17 *b*, is the same as *glutinosa*.

I am unacquainted with Pease's varieties *simplex* and *perplexa*—the latter quoted on the authority of Dr. Hartman, but not recorded by the former author in his list of *Partula*.

I have followed Dr. Hartman in adding Pfeiffer's *mucida* to the synonymy of *varia*, which he says is represented in the British Museum by a dark variety of the latter species. The description and measurements harmonize well, but it appears strange that Pfeiffer should have compared his species to *P. filosa*, which belongs to an entirely different type, instead of to the well-known *varia*.

I cannot agree with Dr. Hartman in his affiliation of Pease's *P. strigata*, a Marquesas ("Marquesas? Rve.," Hartman) species, with *P. varia*, which is an entirely distinct species. Pease's shells were collected by a native missionary residing on Woapo, one of the former group, which is 850 miles distant from Huaheine.

The only species likely to be confounded with *varia* is Pease's *P. assimilis* (= *P. Cookiana*, Mouss.), inhabiting Rarotonga, one of the Cook's Islands, 600 miles from the habitat of the former species. Dr. Hartman records it (Cat. Partula) as a valid species, and very correctly makes *P. Cookiana*, Mouss., a synonym. He also records it (Obs. Gen. Partula, p. 179), and remarks: "This shell may prove to be a local variety of *P. varia*." On page 181, l. c., he doubts *Cookiana* being identical with *assimilis*, and on page 189, l. c., makes both *assimilis* and *Cookiana* pure synonyms of *varia*. Pease, in his description of *assimilis*, remarks: "Comparing large numbers, the above is more abbreviate, whorls more convex, and the aperture narrower." The lip is also less expanded, the spire more turgid, the apex more obtuse and the coloration is comparatively uniform. At any rate, the two species can be distinguished at a glance, and, considering the remote habitats, may be regarded as distinct but closely allied species.

Genus TORNATELLINA, Beck.

T. Philippii, Pfeiffer.

Tornatellina Philippii, Pfeiffer, Zeitsch. Malak., 1849, p. 93; Mon. Hel., iii, p. 524. Pease, Proc. Zool. Soc., 1871, p. 473. Garrett, Proc. Acad. Nat. Sci. Phila., 1879, p. 22; Jour. Acad. Nat. Sci. Phila., 1881, p. 397.

Pupa Philippii, Küster, Pl. XVIII, figs. 20, 21.

Leptinaria Philippii, H. and A. Adams, Gen. Moll., p. 141.

Achatina Philippii (*Leptinaria*), Pfeiffer, Vers., p. 170.

Cionella Philippii, Martens.

This species, though distributed throughout the group, is not plentiful. They were found adhering to the under side of loose stones, beneath dead wood and decaying leaves. I also obtained examples at the Cook's, Marquesas, and received it from one of the Austral Islands.

It may be readily known by its swollen whorls, turgid body, large, compressed, parietal laminæ, and somewhat tortuous columella.

T. oblonga, Pease.

Tornatellina oblonga, Pease, Proc. Zool. Soc., 1864, p. 673; Jour. de Conch., 1871, p. 93; Proc. Zool. Soc., 1871, p. 473. Pfeiffer, Mon. Hel., vi, p. 264. Schmeltz, Cat. Mus. Godeff., v, p. 89. Garrett, Proc. Acad. Nat. Sci. Phila., 1879, p. 21; Jour. Acad. Nat. Sci. Phila., 1881, p. 398.

Tornatellina bacillaris, Mousson, Jour. de Conch., 1871, p. 16, Pl. III, fig. 5. Pfeiffer, Mon. Hel., viii, p. 316. Schmeltz, Cat. Mus. Godeff., v, pp. 89, 90.

Plentiful, and distributed throughout southern Polynesia. Like the preceding, it is a ground species, though sometimes found on the fronds of ferns, and ranges from near the seashore to 2000 or more feet above sea-level.

Prof. Mousson gives an accurate description of *oblonga*, under the name of *bacillaris*, from specimens collected by Dr. Graffe at the Samoa Islands.

I collected Mr. Pease's type examples at Huaheine. Its slender form and nearly vertical simple columella will easily distinguish it.

T. conica, Mousson.

Tornatellina conica, Mousson, Jour. de Conch., 1869, p. 342, Pl. XIV, fig. 8; 1870, p. 128; 1871 (var. *impressa*), p. 16; 1873, p. 106. Pease, Proc. Zool. Soc., 1871, p. 473. Pfeiffer, Mon. Hel., viii, p. 316. Garrett, Proc. Acad. Nat. Sci. Phila., 1879, p. 21; Jour. Acad. Nat. Sci. Phila., 1881, p. 399. Schmeltz, Cat. Mus. Godeff., v, p. 89.

Cionella conica, Paetel, Cat. Conch., p. 106.

Tornatella oblonga, Pease (part), Proc. Zool. Soc., 1864, p. 673.

Not uncommon, and ranges from the Paumotu to the Viti Isles, and was collected by Dr. Graffe on the low coral islands of Ellice's group in central Polynesia.

I forwarded Mr. Pease a number of examples of this species intermixed with *oblonga*, and, supposing the two to be identical, he included it in his diagnosis of the latter species. Having collected hundreds of specimens of both species at the different groups, I do not hesitate to consider them quite distinct. As compared to *oblonga*, it is lighter-colored, more robust, spire more rapidly tapering, body-whorl larger and more or less compressed in the middle. The parietal lamina is larger, and the columella more tortuous.

Mousson's var. *impressa* is not uncommon in eastern Polynesia.

T. SIMPLEX, Pease. Plate II, fig. 21.

Tornatellina simplex, Pease, Proc. Zool. Soc., 1864, p. 673; 1871, p. 473. Pfeiffer, Mon. Hel., vi, p. 266. Garrett, Proc. Acad. Nat. Sci. Phila., 1879, p. 22; Jour. Acad. Nat. Sci. Phila., 1881, p. 398.

Tornatellina Newcombi, var., Schmeltz, Cat. Mus. Godeff., vi, p. 80.

This species is distributed throughout all the groups of islands in southeastern Polynesia; on the ground, in forests.

Mr. Pease's type specimens were collected by me at Tahaa. He either overlooked or inadvertently omitted to mention the small, but constant, parietal lamina in his brief diagnosis. The open umbilicus, small parietal lamina, smooth and simple columella, will distinguish it from any other south Polynesian species.

Though shaped like *T. Newcombi*, which inhabits the Sandwich Islands, it is smaller, the umbilicus larger, the columella simple, *not* biplicate, and the parietal lamina is smaller than in Pfeiffer's species.

T. PERPLEXA, Garrett. Plate II, fig. 23.

Tornatellina perplexa, Garrett, Proc. Acad. Nat. Sci. Phila., 1879, p. 24; Jour. Acad. Nat. Sci. Phila., 1881, p. 398.

Tornatellina bilamellata, Schmeltz (not of Anton), Cat. Mus. Godeff., v, p. 90.

Not uncommon, and ranges throughout the group. Also common to the Austral and Cook's Islands.

As compared with *nitida*, the nearest allied species, it has a more dilated and bidentate columella. The upper denticle is larger and not so acute as in *nitida*. Some examples have the palatal denticles mounted on longitudinal lines of callus.

T. SERRATA, Pease. Plate II, figs. 22, 22 *a*.

Lamellina serrata, Pease, Proc. Zool. Soc., 1860, p. 439; 1871, p. 473.

Tornatellina serrata, Pfeiffer, Mon. Hel., vi, p. 265.

Lamellina lævis, Pease, Proc. Zool. Soc., 1864, p. 672; 1871, p. 473.

Tornatellina lævis, Pfeiffer, Mon. Hel., vi, p. 216.

Not uncommon, and distributed throughout southeastern Polynesia.

For further remarks, see my two papers on the land shells of Rurutu and Cook's Islands, published by the Academy of Natural Sciences of Philadelphia.

T. NITIDA, Pease. Plate II, fig. 24.

Tornatellina nitida, Pease, Proc. Zool. Soc., 1860, p. 439; Jour. de Conch., 1871, p. 93; Proc. Zool. Soc., 1871, p. 473. Pfeiffer, Mon. Hel., vi, p. 264. Garrett, Proc. Acad. Nat Sci. Phil., 1879, p. 22; Jour. Acad. Nat. Sci. Phil., 1881, p. 399.

This species is found abundantly on all the islands in southeastern Polynesia, and ranges northwest as far as the Caroline Islands, where I obtained Mr. Pease's type specimens.

It is a thin transparent species, with a more tapering spire than *oblonga*, with the twisted columella of *conica*, but readily distinguished by the acute plication on the columella.

T. APERTA, Pease. Plate II, fig. 20.

Tornatellina aperta, Pease, Proc. Zool. Soc., 1864, p. 673; 1871, p. 473. Pfeiffer, Mon. Hel., vi, p. 264.

Not uncommon on foliage, and ranges throughout the group. A few examples were taken by me at the Marquesas Islands.

It may be distinguished by its globose-ovate form and the peculiar vertical bidentate crest on the columella.

The animal, which is very active, is subpellucid with dusky tentacles. The foot is oblong, rounded behind, and nearly as long as the shell. The eye-peduncles are stout. Labial tentacles, none. Muzzle large, dilated, and aids in locomotion.

T. PEASEANA, Garrett. Plate II, fig. 19.

Shell imperforate, oblong-ovate, smooth, thin, shining, faintly striated, dark brownish horn-color; spire conical, with nearly planulate outlines and subacute apex; suture faintly impressed; whorls five and a half, convex, moderately increasing, last one large, rounded, not descending in front; aperture large, oblique, truncately ovate, nearly half the length of the shell; peristome thin, straight, regularly curved; parietal region with a prominent, thin, revolving white lamina, which is slightly reflected posteriorly; columella armed with a prominent, nearly vertical, bidentate plait.

Length 5, diam. $2\frac{1}{2}$ mill.

Hab.—Moorea Island.

Very rare on foliage. Closely allied to *aperta*, but much larger, more elongate, darker color and the spire more produced.

Genus VERTIGO, Müller.

V. PEDICULUS, Shuttleworth. Plate III, fig. 42.

Pupa pediculus, Shuttleworth, Bern. Mitth., 1852, p. 296. Pfeiffer, Mon. Hel., iii, p. 557. Schmeltz, Cat. Mus. Godeff., v, p. 89. Mousson (var. *Samoensis*), Jour. de Conch., 1865, p. 117.

Vertigo pediculus, Pfeiffer, Vers., p. 177. (*Alæa*) H. and A. Adams, Gen. Moll., ii, p. 172. Mousson, Jour. de Conch., 1869, p. 341. Pease, Proc. Zool. Soc., 1871, pp. 463, 474. Garrett, Proc. Acad. Nat. Sci. Phila., 1879, p. 19; Jour. Acad. Nat. Sci. Phila., 1881, p. 400.

Pupa Samoensis, "MSS." Schmeltz, Cat. Mus. Godeff., iv, p. 69. (*Sphyradium*) Paetel, Cat. Conch., p. 108.

Pupa nitens, Pease, Proc. Zool. Soc., 1860, p. 439. Pfeiffer, Mon. Hel., vi, p. 335.

Vertigo nitens, Pease, Proc. Zool. Soc., 1871, pp. 463, 474.

Pupa hyalina, "Zelebor" Pfeiffer, Mon. Hel., vi, p. 329.

Vertigo hyalina, Pease, Proc. Zool. Soc., 1871, p. 474.

? *Vertigo nacca*, Gould, Proc. Bost. Soc. Nat. Hist., 1862, p. 280; Otia Conch., p. 237. Pease, Proc. Zool. Soc., 1871, pp. 463, 474.

Pupa nacca, Pfeiffer, Mon. Hel., vi, p. 330.

With the exception of *Stenogyra Tuckeri*, this minute shell has the widest range throughout Polynesia of any species.

Its oblong-ovate form and hyaline texture will easily distinguish it.

For further information in regard to this species, see my paper on the Rurutu Island land shells.

V. TANTILLA, Gould.

Pupa (Vertigo) tantilla, Gould, Proc. Bost. Soc. Nat. Hist., 1847, p. 197. Pfeiffer, Mon. Hel., iii, p. 457. (*Vertigo*) Mousson, Jour. de Conch., 1870, p. 127. (*Vertigo*) Schmeltz, Cat. Mus. Godeff., iv, p. 69. (*Pupilla*) Paetel, Cat. Conch., p. 108.

Vertigo tantilla, Gould, Expl. Ex. Shells, p. 92, fig. 103. (*Alæa*) H. and A. Adams, Gen. Moll., ii, p. 172. Pease, Proc. Zool. Soc., 1871, pp. 460, 463, 474. Garrett, Jour. Acad. Nat. Sci. Phila., 1881, p. 400.

Pupa Dunkeri, "Zelebor" Pfeiffer, Mon. Hel., vi, p. 333.

Vertigo Dunkeri, Pease, Proc. Zool. Soc., 1871, p. 474.

Vertigo armata, Pease, Proc. Zool. Soc., 1871, pp. 461, 474.

Pupa armata, Pfeiffer, Mon. Hel., viii, p. 407.

Vertigo dentifera, Pease, Proc. Zool. Soc., 1871, pp. 462, 474.

Pupa dentifera, Pfeiffer, Mon. Hel., viii, p. 408.

I gathered examples of this small shell at Tahiti, Huaheine, Borabora and Maupiti. In all probability it occurs on the other islands, and ranges west to the Viti group, where Dr. Graffe obtained specimens.

It may be distinguished from the preceding species by its dark color and thin, plicate striæ.

For further remarks, see my paper on the Cook's Island shells, published by the Academy of Natural Sciences of Philadelphia.

Genus SUCCINEA, Draparnaud.

Succineæ are tolerably abundant on all the islands, except Borabora and Maupiti, where I failed to find examples. Like the *Partulæ*, they may be divided into ground and arboreal species.

There are twelve species recorded from this group, some of which are undoubtedly synonyms, and one or two are doubtful inhabitants. The specific characters of the various species are so feebly expressed that their correct determination, by the aid of the brief Latin diagnoses alone, is an almost hopeless task.

S. HUMEROSA, Gould.

Succinea humerosa, Gould, Proc. Bost. Soc. Nat. Hist., 1846, p. 183; Expl. Ex. Shells, p. 18, fig. 19. Pfeiffer, Mon. Hel., ii, p. 520. H. and A. Adams, Gen. Moll., ii, p. 128. Pease, Proc. Zool. Soc., 1864, p. 677; 1871, p. 472.

Succinea Tahitensis, Pease (not of Pfeiffer), Proc. Zool. Soc., 1864, p. 677; 1871, p. 472.

Rather common and widely diffused over Tahiti, where it lives on the ground in forests, and appears to be confined to that island.

It may be distinguished from any other Society Islands species by its broad ovate form, very short mammillated spire, large depressed body-whorl, which usually exhibits a roundly angular shoulder, which suggested the specific name. Dr. Gould gives three whorls, though I can detect two and a half only in my numerous specimens. The color is rufus, pale corneous, yellowish amber and whitish. The revolving sulcations mentioned by the above author are not a constant character, and are common to other Society Islands species.

S. TAHITENSIS, Pfeiffer. Plate II, fig. 2.

Succinea Tahitensis, Pfeiffer, Proc. Zool. Soc., 1846, p. 109; Mon. Hel., ii, p. 522. H. and A. Adams, Gen. Moll., ii, p. 129.

Succinea ovata, "Pease," MS. Carpenter, Proc. Zool. Soc., 1864, p. 675.

Succinea papillata, Carpenter (not of Pfeiffer), Proc. Zool. Soc., 1864, p. 675. Pease, Amer. Jour. Conch., 1867, p. 227; Proc. Zool. Soc., 1871, p. 472. Schmeltz, Cat. Mus. Godeff., v, p. 89.

Abundant on the ground in moist places, and distributed throughout the island of Huaheine.

Dr. Pfeiffer's description agrees much better with this shell than with *humerosa*, and, contrary to the opinion of Mr. Pease, I do not hesitate to consider my determination as correct. The locality "Tahiti" is too frequently used for shells inhabiting other islands in the group to deserve much attention. Mr. Cuming, who collected extensively on Huaheine, could scarcely have failed to discover so common a shell, and may have forgotten the exact locality. It is now well known that a large number of his habitats of species discovered by himself are erroneous. Mr. Pease, who was well acquainted with the locality of his *ovata*, gave the wrong one, "Tahiti," where it does not occur.

It is more nearly related to *humerosa* than to any other species, but may be distinguished by its larger and more produced spire, more contracted body, and light amber-color. Specimens with subangulated body-whorl are not infrequent, and some have obscure transverse sulcations.

Laimodonta conica, Martens and Langk., Don. Bism., p. 57, Pl. III, fig. 13.
Plecotrema Anaaensis, Paetel, Cat. Conch., p. 114.
Melampus conicus, Pfeiffer, Mon. Pneum., iv (*Auriculacea*), p. 319.
? *Melampus Anaaensis*, Pfeiffer, l. c., p. 320.

This species, though ranging from the Paumotu to the Viti Islands, is rarely found in the Society group. It is smaller and not so robust as *L. Bronni* of the Sandwich Isles. The spiral impressed lines are more conspicuous, and the aperture exhibits a heavier deposit of callus in the palate.

Genus PLECOTREMA, H. and A. Adams.

P. MORDAX, Dohrn.

Plecotrema mordax, Dohrn, Mal. Blat., 1859, p. 204. Pease, Jour. de Conch., 1871, p. 93. Martens and Langk., Don. Bism., p. 55, Pl. III, fig. 8. Paetel, Cat. Conch., p. 114.

A few dead specimens found on the seashore on the northeast coast of Tahiti. It is not uncommon on the Paumotu Isls.

The examples now before me are more globose than any Polynesian species known to me. The riblets are rounded and rugose. My specimens average from 5 to 6 mill. in length, and are nearly white with a very broad, light fulvous zone.

Genus DIADEMA, Pease.
Amer. Jour. Conch., 1868, p. 158.
Garrettia, O. Semper, Cat. Mus. Godeff., v, p. 100, 1874.

D. BIANGULATA, Pease. Plate II, fig. 29.

Cyclostoma biangulata, Pease, Proc. Zool. Soc., 1864, p. 674.
Diadema biangulata, Pease, Proc. Zool. Soc., 1871, p. 475. Pfeiffer, Mon. Pneum., iv, p. 56. Garrett, Jour. Acad. Nat. Sci. Phila., 1881, p. 404.
Cyclophorus (Ostodes) biangulatus, Martens and Langk., Don. Bism., p. 58, Pl. III, fig. 16.
Garrettia Scalariformis, Paetel, Cat. Conch., p. 424.
Garrettia biangulata, Schmeltz, Cat. Mus. Godeff., v, p. 100.
? *Cyclophorus biangulatus*, Pfeiffer, Mon. Pneum., iv, p. 114.
? *Cyclomorpha biangulata*, Pfeiffer, l. c., p. 234.

A few examples were found under decaying leaves and confined to a small area on the southwest side of Moorea, where I obtained Mr. Pease's type specimens. The metropolis or specific centre of this species is Aitutake, one of the Cook's or Harvey Islands, where it is found in the greatest profusion.

Its conical shape, brown color and tricarinate body-whorl will readily distinguish it.

Genus OMPHALOTROPIS, Pfeiffer.

This genus was established by the above author for the reception of a group of cyclostomoid shells, which are distinguished by the filiform carina which circumscribes the basal perforation, simple or slightly expanded peristome, and in shape varying from globose-turbinate to elongate-conical.

They are distributed over a vast area extending from southeastern Polynesia to Mauritius and Bourbon. They are entirely absent from the Sandwich Islands, where the only operculated land shells are *Helicinæ*. Two species of *Atropis* only are recorded from the Marquesas Islands; but their existence in that group certainly wants confirmation. Both Mr. Pease's collector and myself searched in nearly all parts of the group without discovering a single example. In all probability the Society Islands are the eastern limits of this group of shells. At any rate I utterly failed to detect them at the Gambier and Paumotu Islands.

In the Society Islands the typical form is represented by a group in which the keel gradually becomes evanescent, as in *Huaheinensis* and *scitula*, or entirely absent, as in *terebralis* and *producta*. The three latter were classed by Mr. Pease in his genus *Atropis*. All the above species, together with *Boraborensis* and *oblonga*, usually have the body or penultimate whorl more or less angulated and frequently with a periphery keel.

The animal of *Huaheinensis* varies from pale cinereous to tawny flesh-color with blackish tentacles, which latter are short, conical, blunt and transversely wrinkled. Eyes very conspicuous, black on enlargements at the hinder base of the tentacles. Head broad, emarginate in front. Muzzle slightly dilated and bilobed in front, and used in aiding locomotion. Foot small, oval, nearly half the length of the shell.

O. Huaheinensis, Pfeiffer.

Hydrocena Huaheinensis, Pfeiffer, Proc. Zool. Soc., 1854, p. 308; Mon. Pneum., ii, p. 163. H. and A. Adams, Gen. Moll., ii, p. 300.

Omphalotropis Huaheinensis, Pfeiffer, Mon. Pneum., iii, p. 177. Mart. and Langk., Don. Bism., p. 58, Pl. III, fig. 17. Pease, Jour. de Conch., 1869, p. 148, Pl. VII, fig. 9. Schmeltz, Cat. Mus. Godeff., v. p. 101. Pease, Proc. Zool. Soc., 1871, p. 476.

Assiminea Huaheinensis, Marten, Ann. Mag. Nat. Hist., 1866, p. 206.

Realia Huaheinensis, Pfeiffer, Mon. Pneum., iv, p. 221. Carpenter, Proc. Zool. Soc., 1871, p. 676.

Hydrocena robusta, "Pease," MS. Carpenter, Proc. Zool. Soc., 1864, p. 676.

Omphalotropis robusta, Crosse, Jour. de Conch., 1869, p. 148 (foot-note), Pl. VII, fig. 3. Schmeltz, Cat. Mus. Godeff., v, p. 208.

Occurs in abundance, and widely diffused over Huaheine. It is also plentiful and of larger size in three or four valleys on the west side of Raiatea. At Moorea, where I obtained a few examples, it is of small size (5 mill.) and has the basal keel nearly or quite obsolete. On the ground in forests.

Pfeiffer's type specimens (9 mill.) were collected at Raiatea, and his var. β (6 mill.) at Huaheine. In one valley on the former island I discovered a large variety which attained a length of 11 mill.

They vary considerably in color: pale luteous, corneous, brown, brownish red, reddish horn-color, rarely with a transverse brown or reddish band on the middle of the body-whorl, which latter is sometimes slightly angulated. The epidermis is very thin, concolored, and the surface is generally more or less eroded. The basal keel is not so distinct as in the typical species inhabiting the western groups.

O. PRODUCTA, Pease.

Realia producta, Pease, Proc. Zool. Soc., 1864, p. 673. Pfeiffer, Mon. Pneum., iv, p. 217.
Omphalotropis producta, Pease, Jour. de Conch., 1899, p. 151, Pl. VII, fig 8.
Atropis producta, Pease, Proc. Zool. Soc., 1871, pp. 471, 476.
Realia elongata, Pease, Amer. Jour. Conch , 1867, p. 225. Pfeiffer, Mon. Pneum., iv, p. 218.
Omphalotropis elongata, Pease, Jour. de Conch., 1869, p. 152, Pl. VII, fig. 4 ; 1871, p. 95.
Atropis elongata, Pease, Proc. Zool. Soc., 1871, p. 476. Schmeltz, Cat. Mus. Godeff., v, p. 101.
Realia scitula, Carpenter (not of Gould), Proc. Zool. Soc., 1864, p. 676.
Hydrocena Raiatensis, Mousson, Jour. de Conch., 1869, p. 67, Pl. V, fig. 5.
Realia Raiatensis, Pfeiffer, Mon. Pneum., iv, p. 215.

This variable species is confined to Raiatea and Tahaa, where it is found on the ground in forests, and is widely diffused over both islands.

Mr. Pease's measurement, $10\frac{1}{2}$ mill., is probably a mistake. I have now before me over 500 examples, the largest of which is 9, and the smallest adult is 6 mill. in length. The first has eight, and the latter seven whorls. I note the following colors: whitish, pale luteous, corneous, different shades of brown, reddish brown, and very rarely with a narrow transverse reddish band on the body-whorl. The aperture varies from pale yellowish white to dark ochraceous, sometimes reddish brown or whitish.

The penultimate whorl is frequently slightly exserted over the body-whorl, which latter is rounded, very rarely subangulated, and the base very narrowly perforated or rimate, but not keeled or angulate. The epidermis, which is very rarely present, is thin and smooth. Sometimes the peristome is considerably expanded and the lip duplicated. There is also considerable variation in the convexity of the whorls. Mr. Pease's *producta*, which he first described, differs none from his *elongata*, except having the whorls more flattened, a character which gradually merges into the latter species. The same variation obtains in *Boraborensis* and *terebralis*.

O. BORABORENSIS, Dohrn. Plate III, fig. 60.

Omphalotropis Boraborensis, Dohrn., Malak. Blat., 1859, p. 203. Pfeiffer, Mon. Pneum., iii, p. 175. Pease, Jour de Conch., 1869, p. 151. Schmeltz, Cat. Mus. Godeff., v, p. 208.
Atropis Boraborensis, Pease, Proc. Zool. Soc., 1871, p. 476.
Realia Boraborensis, Pfeiffer, Mon. Pneum., iv, p. 217.

Plentiful and peculiar to Borabora, where they occur on the ground in the mountain forests. Mr. Schmeltz gives the wrong locality.

The more or less conspicuous, longitudinal, elevated striæ on the middle whorls will readily distinguish it from any other Society Islands species. The general color is pale corneous, sometimes whitish, brownish or brownish rose. The last whorl is more or less distinctly angulated a little below the middle, and frequently with a thread-like keel which winds up the spire. The penultimate whorl is often imbricated or exserted.

Adults are nearly always decorticated. The minute perforation is never carinated, but sometimes exhibits a slight marginal pinch. The vertical aperture is whitish or pale yellowish brown, and the peristome is slightly expanded. The epidermis in young examples is thin, smooth, and the same color as the shell.

O. TEREBRALIS, Gould.

Cyclostoma terebralis, Gould, Proc. Bost. Soc. Nat. Hist., 1847, p. 206; Expl. Ex. Shells, p. 106, fig. 120. Petit, Jour. de Conch., 1850, p. 47.

Omphalotropis terebralis, Pfeiffer, Proc. Zool. Soc., 1852, p. 151. H. and A. Adams, Gen. Mol., ii, p. 300. Pfeiffer, Mon. Pneum., i, p. 307. Pease, Jour. de Conch., 1869, p. 151. Paetel, Cat. Conch., p. 124.

Realia terebralis, Gray, Cat. Phan., p. 219. Pfeiffer, Mon. Pneum., iv, p. 217.

Atropis terebralis, Pease, Proc. Zool. Soc., 1871, p. 476. Schmeltz, Cat. Mus. Godeff., v, p. 102.

Atropis Gouldii, Garr. MS.

Atropis Dohrniana, Garr. MS.

I found this species plentiful on the ground in a lowland forest on the coast of Moorea, and did not find a single example in any other part of the island. It occurs, also, somewhat rarely in three valleys on the northwest side of Tahiti, and more abundantly in the mountain forests of Borabora. On the two latter islands it is confined to an elevation of about 500 feet above sea-level.

The presence of this species in Borabora is somewhat remarkable, as it does not occur on the three intermediate islands. Examples from the latter island, which I have distributed to my correspondents under the name of *Dohrniana*, differ none from Gould's species, except in having a velvety epidermis.

The Moorea shell, to which I gave the provisional name of *Gouldi*, varies from the type in its more attenuated form, the whorls less "imbricated," and the angle on the last one nearly obsolete. It was found associated with the typical *terebralis*, into which it gradually merges.

The color is corneous, grayish olive, rarely luteous under a thin brown or horn-colored smooth or velvety epidermis. In the type the whorls have, as Gould states, an imbricated appearance, but the character is not constant and is more or less evident in several other species inhabiting the group. The last whorl is more or less distinctly angulated and the axis is rimate or imperforate. In old examples, which are more or less decorticated, the aperture is sometimes ochraceous with a pale lip. The size of adults ranges from 4½ to 7 mill. The peristome is frequently obscurely duplicated.

O. SCITULA, Gould.

Cyclostoma scitulum, Gould, Proc. Bost. Soc. Nat. Hist., 1847, p. 206; Expl. Ex. Shells, p. 108, fig. 123. Petit, Jour. de Conch., 1850, p. 47.

Omphalotropis? scitula, Pfeiffer, Proc. Zool. Soc., 1852, p. 151; 1854, p. 307; Mon. Pneum., i, p. 308. H. and A. Adams, Gen. Moll., ii, p. 300. Pease, Jour de Conch., 1869, p. 155.

Realia scitula, Gray, Cat. Phan., p. 220. Pfeiffer, Mon. Pneum., iv, p. 220.
Hydrocena scitula, Pfeiffer, Mon. Pneum., ii, p. 162.
Atropis scitula, Pease, Proc. Zool. Soc., 1871, p. 476. Schmeltz, Cat. Mus. Godeff., v, p. 102.

This protean species is very common and widely diffused throughout all the valleys on the northwest part of Tahiti, and is equally as plentiful in the various valleys on Moorea. On the ground in forests.

Though usually cited as Gould's *scitula*, I have serious doubts of the correctness of the identification. His diagnosis is as follows:—

"T. parva, elongato-conica, tenuis, rufo-cornea, striis incrementi tenuibus solum insculpta, arcte umbilicata; spira elevata, anfr. 6–7 rotundatis, supernis subangulatus; sutura profunda; apertura rotundato-ovata, parva, trientum longitudinis adæquans; perist. simplex, pallidum. Long. 1-5, lat. 1-10 poll." (Gould).

In his remarks he says: "Almost exactly like *Amnicola Sayana*, Anth. It is larger and more ventricose than *C. vallatum*, and is distinguished from *C. terebrale* by its less slender form and unexpanded lip."

The above short diagnosis does not agree very closely with the numerous specimens now before me. His dimensions are too small to accord with our shells. Neither do they resemble Binney's figure of *Amnicola Sayana*. The only Tahiti shell that resembles Binney's figure is *Atropis Bythinellæformis*, which is the same size as Gould's species, but the whorls are *not* "supernis subangulatus."

The species under consideration is 6 mill. long and 3 mill. in diameter. The spire is oblong-conical with slightly convex outlines; whorls six, convex, smooth, the penultimate frequently projecting over the suture as in *terebralis*, and sometimes filocarinated at the angle. The last whorl is more or less distinctly angulated, rarely with a thread-like keel; sometimes rounded. The axis is rimate or minutely perforated and the margin slightly compressed, rarely filocarinated, sometimes simple, as in *Atropis*. The nearly vertical aperture is ovately rounded, with a slight posterior angle and about one-third the length of the shell.

O. oblonga, Pfeiffer. Plate III, fig. 59.

Hydrocena oblonga, Pfeiffer, Proc. Zool. Soc., 1854, p. 305; Mon. Pneum., ii, p. 159. H. and A. Adams, Gen. Moll., ii, p. 299.
Omphalotropis oblonga, Pease, Jour. de Conch., 1869, p. 154.
Atropis oblonga, Pease, Proc. Zool. Soc., 1871, p. 476.
Realia oblonga, Pfeiffer, Mon. Pneum., iv, p. 213.

Abundant on the ground in forests, on the north side of Moorea.

I think Pfeiffer is wrong in assigning this species to the Marquesas Islands. The Moorea shells coincide so nearly with his description, that I do not in the least hesitate in referring them to his species. I am also inclined to believe it only a form of *scitula*.

My largest examples are 7 mill. long by 3½ in diameter, being a little larger than *scitula.* The shape is oblong-conical, rimately perforated, whorls six, moderately convex, margined by a thread-like keel, which latter is very conspicuous on the sub-angulate body-whorl. The base is more or less compressed on the margin of the perforation. Nearly all my examples are decorticated and have a whitish or yellowish aperture. The general color is pale corneous or pale fulvous.

The peristome is slightly expanded at the base and over the perforation, and the margins united by a deposit of callus.

Color variable: whitish, corneous, fulvous, brownish, ruddy brown, rarely pale luteous. Aperture concolored, sometimes ochraceous. The thin brownish epidermis is rarely present on adults. The striæ of growth are scarcely visible under a strong lens.

Genus ATROPIS, Pease.

The above genus was instituted by Mr. Pease (Proc. Zool. Soc., 1871, p. 463) for the reception of those species of *Omphalotropis* which are devoid of the basal carination. Although he ranked the eliminated group as subgeneric, in the same paper (p. 476) he used the name in a generic sense and records eighteen species. His "*A. affinis*" is, by Von Martens, Paetel, Schmeltz and myself, referred to the genus *Scalinella.* His "*A. ochrostroma*" has, like *Omphalotropis Huaheinensis*, a more or less obsolete keel and should be transferred to that genus. His "*A. insularis*," and probably *A. exigua*, are *Chondrellæ.*

After eliminating all the Society Islands species of the *scitula* and *terebralis* type there remain several species which are nothing more than smooth *Scalinellæ.* These only I retain under the name of *Atropis*, and it may be characterized as follows:—

Shell small, rimate or minutely perforated, ovate-conic or elongate-conical, smooth; whorls rounded, suture profound, body-whorl usually turgid; aperture subcircular; peristome simple, sometimes indistinctly duplex, continuous and briefly adhering to the penultimate whorl.

A. ABBREVIATA, Pease.

Realia abbreviata, Pease, Proc. Zool. Soc., 1864, p. 674. Pfeiffer, Mon. Pneum., iv, p. 212.

Omphalotropis abbreviata, Pease, Jour. de Conch., 1869, p. 155, Pl. VII, fig. 5.

Atropis abbreviata, Pease, Proc. Zool. Soc., 1871, p. 476. Schmeltz, Cat. Mus. Godeff., v, p. 102.

A somewhat rare species, found on the ground on the northwest side of Tahiti.

It may be distinguished by its oblong-ovate form, rounded whorls and ventricose body. The axis is subperforated or rimate and the apex rounded. Under the brownish or olivaceous epidermis the shell is pale horn-color, rarely light olive or ruddy corneous. The aperture is concolored or pale yellowish brown.

A. Vescoi, Dohrn.

Hydrocena Vescoi, Dohrn, Malak. Blatt., 1859, p. 202. Pfeiffer, Mon. Pneum., iii, p. 172.

Omphalotropis Vescoi, Pease, Jour. de Conch., 1869, p. 153.

Atropis Vescoi, Pease, Proc. Zool. Soc., 1871, p. 476.

Realia Vescoi, Martens and Langk., Don. Bism., p. 58, Pl. III, fig. 20. Pfeiffer, Mon. Pneum., iv, p. 210.

More rare than the preceding species, and only occurred to my notice in one valley on the north side of Tahiti, where they were found on the side of a ravine about 1500 feet above sea-level

Smaller and more solid than *abbreviata*, and more or less decorticated. Usually ruddy corneous with a luteous or ochraceous aperture.

A. viridescens, Pease.

Cyclostoma viridescens, Pease, Proc. Zool. Soc., 1861, p. 243.

? *Realia viridescens*, Pfeiffer, Mon. Pneum., iii, p. 171; iv, p. 209.

Blanfordia viridescens, Carpenter, Proc. Zool. Soc., 1864, p. 676.

Omphalotropis viridescens, Pease, Jour. de Conch., 1869, p. 153, Pl. VII, fig. 7.

Atropis viridescens, Pease, Proc. Zool. Soc., 1871, p. 476. Schmeltz, Cat. Mus. Godeff., v, p. 101.

Not uncommon, and widely diffused over Huaheine. It also occurs sparingly, of larger size, in a single valley on the southeast part of Raiatea. On the ground in forests, and ranges from 100 to 500 feet above sea-level.

Mr. Pease's type specimens were collected by me at the former location. His description being very short, I redescribe it as follows:—

Shell rimate, elongate-conic, rather thick, smooth, under the lens finely striated, corneous, rarely brownish or olivaceous, aperture whitish or pale luteous; spire elongate-conic, with slightly convex outlines; apex subacute; suture deep; whorls 7–8½, strongly convex or convexly rounded, slowly and somewhat irregularly increasing, last one rounded at the base; aperture vertical, orbicular-ovate, nearly one-fourth the length of the shell; peristome continuous, straight or slightly expanded at the base, rarely duplicated and briefly adhering to the penultimate whorl.

Length 7–8, diam. 2½–2⅔ mill.

They are frequently denuded of the thin, smooth epidermis, and some have a more rapidly tapering spire than others. The Raiatea shells are usually corneous, rarely brownish and never olivaceous

A. Bythinellæformis, Garrett. Plate III, fig. 73.

Shell perforated, oblong, conical, rather thin, scarcely shining, smooth, corneous, or light brownish under a thin epidermis; spire oblong, convexly conical, apex rounded, suture profound; whorls six, strongly convex, last one rounded, one-third the length of the shell; aperture rather small, vertical, nearly round; peristome obsoletely doubled, continuous, slightly adhering to the penultimate whorl and very slightly expanded.

Length 5½, diam. 3 mill.

Hab.—Tahiti and Moorea Islands.

This small species, which is somewhat rare, was taken in a single valley on the north side of Tahiti, at an elevation of about 1500 feet above sea-level. A few examples were found in a small area in a lowland forest on the north coast of Moorea.

It is shaped almost exactly like Binney's figure of *Bythinella Nicklineana*. All the specimens, ten in number, now before me, have the peristome slightly doubled or duplicated. As compared with *abbreviata*, it is smaller, more slender, the aperture smaller, the whorls more rounded and basal perforation larger.

A. OBESA, Garrett. Plate III, fig. 72.

Shell small, perforated, solid, ovate-globose, decorticated, smooth, dull whitish horn-color, with a whitish or yellowish aperture; spire abbreviately conical, with an obtuse apex; suture profound; whorls five, convex, last one large, rounded; aperture vertical, orbicular-ovate, nearly half the length of the shell; peristome continuous, simple, straight, regularly curved, base slightly expanded.

Height 4, diam. 3 mill.

Hab.—Tahiti, rare, in a single valley on the northwest part of the island.

As compared with *Vescoi*, the nearest allied species, it is more abbreviate, the body more turgid and the spire shorter.

Genus SCALINELLA, Pease.

S. TAHITENSIS, Pease.

Cyclostoma Tahitensis, Pease, Proc. Zool. Soc., 1861, p. 243.

Hydrocena? Tahitensis, Pfeiffer, Mon. Pneum., iii, p. 173.

Scalinella Tahitensis, Pease, Jour. de Conch., 1869, p. 58, Pl. VII, fig. 1; Proc. Zool. Soc., 1871, p. 475. Mart. and Lang., Don. Bism., p. 59, Pl. IV, fig. 3. Schmeltz, Cat. Mus. Godeff., v, p. 102.

Realia Tahitensis, Pfeiffer, Mon. Pneum., iv, p. 216.

Not uncommon, and widely diffused over Huaheine, where it occurs on the ground in forests. So far it has not been detected on any other island in the group. It appears strange that Mr. Pease should have named this species *Tahitensis*, when he was well aware that his type specimens were collected by me at Huaheine and *not* "Tahiti." His description being very brief, I add the following:—

Shell rimate, elongate-conical, moderately thick, pale cinereous or whitish horn-color beneath a brownish epidermis, which is rarely present; aperture concolored or various shades of ochraceous with a whitish peristome; spire elongate, convexly conic, apex obtuse; whorls 6–7, rounded, the first two or three smooth, the following ones with small longitudinal compressed ribs, about twenty on the body-whorl, which latter is rounded at the base; aperture slightly oblique, subcircular, nearly one-third the length of the shell; peristome continuous, slightly expanded and usually adhering to the penultimate whorl.

Length 6, diam. $2\frac{1}{2}$ mill.

Generally decorticated and more or less eroded.

S. COSTATA, Pease.

Hydrocena costata, Pease, MS. Coll. Pease, 1863.

Hydrocena Taheitensis, Carpenter (not of Pease), Proc. Zool. Soc., 1864, p. 676.

Realia (Scalinella) costata, Pease, Amer. Jour. Conch., 1867, p. 216.

Scalinella costata, Pease, Jour. de Conch., 1869, p. 158, Pl. VII, fig. 2. Schmeltz, Cat. Mus. Godeff., v, p. 102.

Realia costata, Pfeiffer, Mon. Hel., iv, p. 216.

Very numerous on the ground in the lowland forests of Tahaa, where it is peculiar. It differs from *Taheitensis* in its larger size, more robust form, more turgid body, and the ribs are more numerous.

S. MOUSSONI, O. Semper. Plate III, fig. 71.

Taheitia Moussoni, "O. Semper," Schmeltz, Cat. Mus. Godeff., v, p. 102. Pfeiffer, Mon. Pneum., iv, p. 21 (name only).

Not uncommon, and confined to the small island of Maupiti, where they occur on the ground in forests.

The above name appears without description. I describe it as follows:—

Shell rimate, rather slender, elongate conical, rather thick, cinereous, beneath a brownish or olivaceous epidermis; aperture rarely yellowish; spire elongate, obtuse, with subplanulate outlines; whorls six and a half, strongly convex, apical ones smooth, the others with crowded, longitudinal ribs, about thirty on the rounded body-whorl; aperture roundly ovate, vertical, nearly a third the length of the shell; peristome continuous, somewhat patulous, adhering to the penultimate whorl.

Length 5, diam. 2 mill.

More slender and smaller than *Taheitensis*, riblets more crowded and more numerous, body smaller and the aperture generally more oval.

Genus HELICINA, Lamarck.

H. MAUGERIÆ, Gray. Plate III, figs. 64, 65, vars.

Helicina Maugeriæ, Gray, Zool. Jour., i, p. 251; Beech. Voy., Pl. XXXVIII, fig. 25. Sowerby, Thes. Conch., Pl. III, fig. 55. (*Emoda*) H. and A. Adams, Gen. Moll., ii, p. 304. Pfeiffer, Mon. Pneum., i, p. 348. Mart. and Lang., Don. Bism., p. 61, Pl. III, fig 22. Pease, Proc. Zool. Soc., 1871, p. 476. Schmeltz, Cat. Mus. Godeff., v, p. 99.

This large and beautiful species is very plentiful on the trunks of trees and low bushes, and is confined to the upper parts of the valleys on the east and west sides of Raiatea, but is not found on the north and south portions of the island.

The type is white, rarely lemon-yellow, with a dark red dorsal and basal band, and saffron-yellow callus. The following varieties occur:—

a. With two narrow reddish dorsal lines, with or without the basal band.

b. Excepting the basal callus, uniform white.

c. Uniform lemon-yellow

d. White, with reddish spire.

All the above varieties are found associated with the type. Operculum pale amber-color.

Var. RUBICUNDA, Pease. Plate III, fig. 65.

Helicina rubicunda, "Pease," Carpenter, Proc. Zool. Soc., 1864, p. 676.

Helicina Maugeriæ, var. *rubicunda*, Pease, Amer. Jour. Conch., 1867, p. 227; Proc. Zool. Soc., 1871, p. 476.

Helicina rubicunda, Schmeltz, Cat. Mus. Godeff., v, p. 99.

I first discovered this well-marked variety in 1871, at Fatimu, on the southwest coast of Raiatea, where the typical *Maugeriæ* does not occur. I took about 200 examples from beneath dead wood and loose stones. In 1874, during a spell of heavy rains, I visited the same location and found the place converted into a swamp, and gathered nearly a thousand specimens from the trunks of trees, the rains having driven them from their usual shelter. At Viaau, a few miles to the northward of Fatimu, I found a second colony drowned out and crawling up the trunks of trees. Both locations are on the lowlands, near the seashore, where the type with a yellow base does not occur.

It may be distinguished by its red or orange red callus; otherwise the coloration is similar in the two varieties.

Var. ALBINEA, Pease. Plate III, fig. 64.

Helicina bella, "Pease," Carpenter, Proc. Zool. Soc., 1864, p. 676.

Helicina Maugeria, var. *albinea*, Pease, Proc. Zool. Soc., 1871, pp. 466, 476.

This variety is restricted to a single valley on the east side of Tahaa (not "Raiatea," as stated by Pease). It may be characterized by its more depressed form, sharper keel and white basal callus; otherwise the coloration and markings are the same as the typical *Maugeriæ*.

H. FLAVESCENS, Pease.

Helicina Pacifica, Pease, Amer. Jour. Conch., 1865, p. 291; 1866, p. 82, Pl. V, fig. 7.

Helicina flavescens, Pease, Amer. Jour. Conch., 1867, p. 228, Pl. XV, fig. 25; Proc. Zool. Soc., 1871, pp. 467, 476. Schmeltz, Cat. Mus. Godeff., v, p. 99. Pfeiffer, Mon. Pneum., iv, p. 260. Garrett, Jour. Acad. Nat. Sci. Phil., 1881, p. 381.

Helicina pisum, Hombr. and Jacq. (not of Philippi), Voy. Pol. Sud, v, p. 44, Pl. XI, figs. 18–22. Pfeiffer, Mon. Pneum., ii, p. 185.

Helicina straminea, Pease, MS. (not of Morelet), Schmeltz, Cat. Mus. Godeff., v, p. 99.

Helicina Tahitensis, Pease, Proc. Zool. Soc., 1871, pp. 466, 476. Schmeltz, Cat. Mus. Godeff., v, p. 98. Pfeiffer, Mon. Pneum., iv, p. 256.

This, the most abundant species, is not only generally diffused throughout the group, but is also equally as common and widely distributed throughout the Harvey Islands, 500 miles to the southward and westward. It is confined to the lowlands in close proximity to the seashore where it is gregarious beneath stones.

H. ALBOLABRIS, Hombron and Jacquinot.

Helicina albolabris, Homb. and Jacq., Voy. Pol. Sud, v, p. 45, Pl. XI, figs. 23–26. Pfeiffer, Mon. Pneum., ii, p. 186. Pease, Proc. Zool. Soc., 1871, p. 476.

Helicina solida, Pease, Proc. Zool. Soc., 1864, p. 673. Mart. and Lang., Don. Bism., p. 60, Pl. III, fig. 24. Pfeiffer, Mon. Pneum., iv, p. 252.

Helicina solidula, Frauenfeld (not of Gray), Verh. Zool. Bot. Ges. Wien, xix, p. 879.
Helicina crassilabris, Schmeltz (not of Philippi), Cat. Mus. Godeff., v, p. 99.

A common species, peculiar to Tahiti, where they are found on the trunks of trees and bushes, and are widely diffused throughout the island. They exhibit considerable variation in size, color and in the height of the spire. The prevailing tint is whitish or yellowish white, rarely lemon-yellow or uniform reddish of various shades, or the two former colors with reddish spire, and more rarely with a dorsal reddish band. The peristome is thick and white, and the basal callus, which is usually of the latter color, is sometimes pale bluish white or lemon-yellow. Operculum light yellowish horn-color.

Major diam. 5–9 mill.

H. CORRUGATA, Pease. Plate III, fig. 62, 62 *a*, 62 *b*.

Helicina corrugata, Pease, Proc. Zool. Soc., 1864, p. 673. Pfeiffer, Mon. Pneum., iv, p. 252.

Not abundant, and, so far as known, is confined to Raiatea, where it occurs on the ground, and sometimes on the trunks of trees.

It may be distinguished by its more or less depressed spire, thin texture, sharp, slightly expanded lip, which is emarginated above the cárinate periphery, and by the slight groove which circumscribes the basal callus. The color is pale reddish brown, corneous or pale straw-yellow, rarely variegated.

Diam. 5 mill.

H. RUSTICA, Pfeiffer.

Helicina pallida, Pfeiffer (not of Gould), Zeits. Malak., 1848, p. 86.
Helicina rustica, Pfeiffer, Chem., ed. 2d, No. 25, p. 26, Pl. IX, figs. 26–29; Mon. Pneum., i, p. 357. Gray, Cat. Phan., p. 258. (*Idesa*) H. and A. Adams, Gen. Moll., ii, p. 304. Pease, Proc. Zool. Soc., 1871, p. 476.
Helicina rugulosa, Pease, Amer. Jour. Conch., 1868, p. 157, Pl. XII, fig. 2; Proc. Zool. Soc., 1871, p. 476. Pfeiffer, Mon. Pneum., iv, p. 258.

This small species, which is not uncommon, is generally diffused throughout the group, and is found on the ground, ranging from the lowlands near the seashore to 500 feet above sea-level.

Mr. Pease's *rugulosa* is without doubt a synonym of *rustica*. The oblique ribs or coarse striæ vary from costulate to striate. The small size, uniform color, which is usually pale corneous, sometimes light reddish brown or luteous, depressed body-whorl and straight simple peristome will distinguish it. Some examples are smaller (2¼ mill.) than the dimensions given by Pfeiffer and Pease, and have a more elevated spire and less depressed body-whorl.

H. MINIATA, Lesson. Plate III, figs. 63, 63 *a*.

Helicina miniata, Lesson, Voy. Coquille, p. 349, Pl. XIII, fig. 9. Pfeiffer, Mon. Pneum., i, p. 349. Gray, Cat. Phan., p. 251. (*Emoda*) H. and A. Adams, Gen. Moll., p. 304. Mart. and Lang., Don. Bism., p. 60, Pl. III, fig. 23. Pease, Proc. Zool. Soc., 1871, p. 476.
Helicina rufescens, "Pease," MS. Carpenter, Proc. Zool. Soc., 1864, p. 676.

Helicina Rolvii, Carpenter (not of Pfeiffer), Proc. Zool. Soc., 1864, p. 676. Schmeltz, Cat. Mus. Godeff., v, p. 207.

Helicina albolabris, Schmeltz (not of Homb. and Jacq.), Cat. Mus. Godeff., v, p. 98.

M. Lesson's description, which Pfeiffer has copied, being very brief, I redescribe it as follows:—

Shell solid, conoid, opaque, smooth, somewhat shining, with crowded, faint striæ; color variable, generally brownish red, gradually fading on the body-whorl into whitish, pale yellowish or corneous; aperture and basal callus white or bluish white; spire convexly conoid; whorls $4\frac{1}{2}$–5, flatly convex; aperture very oblique, small, semi-oval; peristome slightly expanded, thickened, somewhat labiate, emarginate above the periphery; columella short, arcuate; callus semicircular, thickened towards the extremities of the peristome, Operculum yellowish horn-color.

Major diam. 9, less. diam. 7, height 6 mill.

Hab.—Borabora Island.

Lesson's shells were procured in the same location, where it is peculiar. They occur abundantly on the trunks and foliage of trees and bushes in the mountain forests.

It is subject to the following variations:—

a. Uniform white.

b. Uniform yellow, with white callus.

c. Pale lemon-yellow, with a spiral brownish red band.

H. INCONSPICUA, Pfeiffer.

Helicina inconspicua, Pfeiffer, Zeits. Malak., 1848, p. 86; Mon. Pneum., i, p. 357. Chemnitz, ed. 2d, p. 26, Pl. IX, figs. 18–21. Gray, Cat. Phan., p. 258. (*Idesa*) H. and A. Adams, Gen. Moll., ii, p. 304. Pease, Proc. Zool. Soc., 1871, p. 476. Schmeltz, Cat. Mus. Godeff., v, p. 99.

Helicina exigua, Hombron and Jacquinot, Voy. Pol. Sud, v, p. 46, Pl. XI, figs. 32–35. Pfeiffer, Mon. Pneum., ii, p. 187. Pease, Proc. Zool. Soc., 1871, p. 476.

Helicina minuta, Carpenter (not of Sowerby), Proc. Zool. Soc., 1864, p. 676.

Helicina decolorata, "Mousson," Schmeltz, Cat. Mus. Godeff., v, p. 99.

This, the smallest species inhabiting the group, is not uncommon, and is diffused throughout all the islands, where they occur on the ground in forests, and range from near the seashore to 1000 feet above sea-level. I also obtained examples at the Gambier Islands = Mangareva, which differed none from Society Islands specimens. It is *H. exigua*, H. and J.

The peristome, though usually straight and simple, is occasionally slightly expanded, and they vary slightly in the depression of the body-whorl. The coloration is uniform reddish brown, brownish horn-color, corneous, and more rarely luteous horn-color. The operculum is corneous, with a wide flat external ridge. Specimens collected at Maupiti are frequently marked by fugations, delicate spiral lines similar to *H. flavescens*.

H. MINUTA, Sowerby.

Helicina minuta, Sowerby, Proc. Zool. Soc., 1842, p. 7; Thesaur. Conch., p. 13, Pl. I, figs. 40, 41. Pfeiffer, Mon. Pneum., i, p. 391. Chemnitz, ed. 2d, p. 54, Pl. IV, figs. 24–27. Gray, Cat. Phan., p. 281. (*Pachystoma*) H. and A. Adams, Gen. Moll., ii, p. 285. Pease, Proc. Zool. Soc., 1871, p. 476. Schmeltz, Cat. Mus. Godeff., vi, p. 99. Garrett, Proc. Acad. Nat. Sci. Phil., 1879, p. 29.

Helicina discolor, Muhlfeldt, MS., Anton, Vers., p. 53. (Ex. Pfeiffer.)

Helicina flammeata, Muhlfeldt, MS., l. c. (Ex. Pfeiffer.)

This small species is confined to Tahiti and Moorea, where it lives beneath decaying vegetation.

Sowerby's type specimens were collected by Cuming at Rurutu = "Oheatora," one of the Austral Islands.

Some examples exhibit the delicate pilose fugacious striæ as mentioned in my remarks on *inconspicua* and *flavescens*. The color is reddish brown, straw-yellow, corneous or dull reddish.

Major diam. 4½ mill.

H. DISCOIDEA, Pease. Plate III, figs. 67, 67 *a*, 67 *b*.

Helicina discoidea, Pease, Amer. Jour. Conch., 1867, p. 226; Proc. Zool. Soc., 1871, p. 476. Pfeiffer, Mon. Pneum., iv, p. 286.

Helicina albolabris, Carpenter (not of Homb. and Jacq.), Proc. Zool. Soc., 1864, p. 673.

A somewhat scarce species, found only at Tahaa, where it lives on the ground in the lowland forests.

When Mr. Pease described this species he gave the correct locality; but in his catalogue of Polynesian land shells he gives the wrong habitat, "Tahiti," where it does not occur.

It has the sulcate base of *corrugata*, but is more depressed, and the upper surface of the whorls is more or less corrugated by coarse transverse ribs or undulations. The periphery is carinated, and the color is dull reddish brown, rarely pale yellowish horn-color.

H. SUBRUFA, Pease, MS. Plate III, figs. 68, 68 *a*, 68 *b*.

Helicina subrufa, "Pease," Carpenter, Proc. Zool. Soc., 1864, p. 676.

Helicina minuta, Carpenter (not of Sowerby), l. c.

Helicina turbinella, "Pease," Carpenter (not of Pfeiffer), l. c.

Shell depressly conoid, rather thin, somewhat shining, faintly striated; color variable; reddish brown, horn-color, lemon-yellow, rarely with a dorsal reddish band; spire more or less depressly conoid, subacute; suture linear; whorls 4–4½, convex or flatly convex, rather rapidly increasing, last one somewhat depressed, not descending in front, rounded or obscurely angulated on the periphery; base flatly convex; aperture very oblique, subtriangular-ovate; peristome slightly expanded, sometimes slightly receding above the periphery, obtusely angulate at its junction with the short receding columella; basal callus thin, concolored.

Major diam. 4½–6, height 3–3½ mill.

Hab.—Raiatea and Borabora.

On the ground in forests. Raiatea examples are larger and more depressed than Borabora specimens. It is very closely allied to *minuta*, but may be distinguished by its more effuse aperture, more expanded lip and larger size.

H. FABA, Pease, MS. Plate III, figs. 61, 61 *a*, 61 *b*.

> *Helicina faba*, "Pease," Carpenter, Proc. Zool. Soc., 1864, p. 676. Pease, Amer. Jour. Conch., 1867, p. 226. (Name only.)
>
> *Helicina albolabris*, Carpenter (not of Philippi), l. c.

Shell depressly conoid, rather thin, slightly shining, smooth, faintly striated; reddish brown, corneous, pale straw-yellow, rarely bifasciate; spire depressly conoid or convex, apex subacute; whorls four, subplanulate or slightly convex, rapidly increasing, last one not deflected in front, depressed above, with a more or less prominent compressed keel on the periphery; suture linearly impressed; base convex; aperture very oblique, subovate; peristome slightly expanded, thickened within, slightly emarginate above, a little produced at the carination and angulated at its junction with the short receding columella; callus rather thin, spreading, concolored or whitish. Operculum corneous or amber-color.

Major diam. 6, less. 5, height $3\frac{3}{4}$ mill.

Hab.—Raiatea and Moorea.

The above is the size of my largest Raiatea specimens. They are not very plentiful, and are found adhering to the trunks of trees. The Moorea shells are more rare and more globose in shape as well as smaller than the Raiatea examples. The banded variety occurs at Moorea.

As compared with *albolabris*, it is smaller, thinner, more shining, and the shape of the peristome is quite different in the two species. In size, texture and color it is more nearly related to *corrugata*, but may be distinguished from that species by its more turbinate form and the absence of the basal groove.

H. SIMULANS, Garrett. Plate III, figs. 66, 66 *a*, 66 *b*.

Shell depressed, lenticular, rather thin, faintly striated, pale brownish horn-color, or light straw-yellow; spire depressly conoid; suture linearly impressed; whorls four, very slightly convex, last one depressed, not deflected in front, carinated on the periphery, keel rib-like, obtuse; base convex; aperture very oblique, rather large, semi-elliptical; peristome expanded, thin, very slightly receding above, angulate at the junction with the short receding columella; basal callus thin, concolored.

Major diam. 6, height 3 mill.

Hab.—Tahiti. On bushes.

Shaped like *corrugata*, but wants the basal groove of that species.

H. RAIATENSIS, Garrett. Plate III, figs. 69, 69 *a*, 69 *b*.

Shell depressly conoid, rather thin, slightly shining, conspicuously striate, luteous or whitish horn-color, marbled and spotted with opaque white; spire depressly conoid; suture linearly impressed; whorls four and a half, convex, regularly and rapidly increasing, not deflected in front, last one depressed, rounded on the periphery, flatly convex beneath; aperture oblique, wide, semioval; peristome straight, slightly thickened; columella short and receding; basal callus thin, nearly concolored.

Major diam. 5, height 3 mill.

Hab.—Raiatea.

A few examples were found amongst decaying vegetation, on the west side of Raiatea, but not detected in any other part of the group.

It is closely allied to *rustica* in the form of the shell, and the shape of the peristome is quite similar in the two species. It may, however, be at once distinguished by its larger size, lighter texture, smoother and more shining surface and different color, as well as the more receding columella.

Genus CHONDRELLA, Pease.

C. PARVA, Pease. Plate III, fig. 41.

Cyclostoma parvum, Pease, Proc. Zool. Soc., 1864, p. 674.

Chondrella parva, Pease, Proc. Zool. Soc., 1871, pp. 465, 476. Pfeiffer, Mon. Pneum., iv, p. 294.

Not uncommon, and ranges throughout the group. I also took a few specimens at the Marquesas Islands. They occur amongst dry dead leaves, under stones and dead wood.

About the size and shape of *Assiminea nitida*, with rounded whorls, pale horn-color, sometimes ruddy corneous, and varies in size and length of the spire.

C. INSULARIS, Crosse.

Hydrocena insularis, Crosse, Jour. de Conch., 1865, p. 223, Pl. VI, fig. 7.

Omphalotropis insularis, Pease, Jour. de Conch., 1869, p. 154.

Atropis insularis, Pease, Proc. Zool. Soc., 1871, p. 476.

Realia insularis, Pfeiffer, Mon. Pneum., iv, p. 212.

This species, which I first discovered at the Gambier Islands, where M. Crosse's examples were collected, is also common to Tahiti and Moorea. In size it is intermediate between *parva* and *striata*, but is of a more ruddy color, and, like the former, is smooth.

C. STRIATA, Pease. Plate III, fig. 40.

Chondrella striata, Pease, Proc. Zool. Soc., 1871, p. 477. Pfeiffer, Mon. Pneum., iv, p. 294. Garrett, Proc. Acad. Nat. Sci. Phila., 1879, p. 28; Jour. Acad. Nat. Sci. Phila., 1881, p. 408.

Hydrocena striata, Schmeltz, Cat. Mus. Godeff., v, p. 100.

Hydrocena subinsularis, Mousson, MS.

Much more abundant than the preceding species, and occurs in equal abundance at the Austral and Harvey Islands.

Its smaller size, ruddy color and spiral striæ will readily distinguish it from *C. parva*.

Genus TAHEITIA, H. and A. Adams.
Ann. Nat. Hist., 1863, p. 19.

This genus was established for the reception of those specimens of *Truncatella* characterized by the more or less porrected peristome and the elevated laminæ on the operculum. The shell is always thinner and the costæ more compressed than *Truncatella.* The lip is sharper, more expanded, and they inhabit a different station, being found far inland, and not near high-water mark, as in the latter genus.

Mr. Pease, in his list of Polynesian shells, erroneously refers *T. Vitiensis*, Gld., to *Taheitia.*

T. PORRECTA, Gould.

Truncatella porrecta, Gould, Proc. Bost. Soc. Nat. Hist., 1846, p. 40; Expl. Ex. Shells, p. 8, fig. 127. Pfeiffer, Mon. Pneum., ii, p. 7.

Taheitia porrecta, Pease, Proc. Zool. Soc., 1871, p. 477.

This species only occurred to my notice in one location, about one mile up Papenoo valley, Tahiti.

It is 6 mill. long, pale luteous horn-color, the costæ rather distant, and sixteen or seventeen on the last whorl.

T. PALLIDA, Pease. Plate III, fig. 76.

Taheitia pallida, Pease, Amer. Jour. Conch., 1867, p. 229; Proc. Zool. Soc., 1871, p. 477.

Truncatella porrecta, Schmeltz (not of Gould), Cat. Mus. Godeff., v, p. 104.

Truncatella pallida, Schmeltz, l. c., p. 208. Pfeiffer, Mon. Pneum., iv, p. 20.

Very abundant in the lowland forests, and is generally distributed throughout the group. I have found them half a mile inland associated with Helices and cyclostomoid shells.

It is larger and not so much porrected as the preceding species.

Genus ASSIMINEA, Leach.

A. NITIDA, Pease.

Hydrocena nitida, Pease, Proc. Zool. Soc., 1864, p. 674.

Assiminea nitida, Pease, Jour. de Conch., 1864, p. 165, Pl. VII, fig. 11; Proc. Zool. Soc., 1871, p. 476. Schmeltz, Cat. Mus. Godeff., v, p. 103. Garrett, Proc. Acad. Nat. Sci. Phil., 1879, p. 29; Jour. Acad. Nat. Sci. Phil., 1881, p. 408.

? *Realia nitida*, Pfeiffer, Mon. Pneum., iv, p. 212.

Hydrocena parvula, Mousson, Jour. de Conch., 1865, p. 184; 1873, p. 108.

Omphalotropis parvula, Pease, Jour. de Conch., 1869, p. 155; Proc. Zool. Soc., 1871, p. 476. Paetel, Cat. Conch., p. 124.

Assiminea parvula, Pease, Proc. Zool. Soc., 1871, p. 476. Schmeltz, Cat. Mus. Godeff., v, p. 103.

Realia parvula, Pfeiffer, Mon. Pneum., iv, p. 213.

Assiminea lucida, Pease, Jour. de Conch., 1869, p. 166, Pl. VII, fig. 10; Proc. Zool. Soc., 1871, p. 476.

Assiminea ovata, "Pease," Schmeltz, Cat. Mus. Godeff., v, p. 103.

Hydrocena similis, Baird, Cruise of the Curacoa.

Generally distributed throughout southern Polynesia. For further information in regard to this species, see my paper on the Cook's Island shells.

Recapitulation.

The following list will show the distribution of the land shells over the seven islands:—

	Tahiti.	Moorea.	Huaheine.	Raiatea.	Tahaa.	Borabora.	Maupiti.
Microcystis verticillata, Pse.,		x	x				
Microcystis simillima, Pse.,				x			
Microcystis normalis, Pse.,	x	x	x				
Microcystis Discordiæ, Garr.,	x	x	x	x	x	x	x
Microcystis cultrata, Gld.,	x						
Microcystis angustivoluta, Garr.,		x					
Microcystis scalpta, Garr.,					x		
Trochonanina conula, Pse.,	x	x	x	x	x	x	x
Trochonanina calculosa, Gld.,	x	x	x	x	x	x	x
Trochonanina Taheitensis, Garr.,	x						
Trochonanina subrugosa, Garr.,	x	x					
Zonites Mooreana, Garr.,		x					
Trochomorpha trochiformis, Fer.,				x	x		
Trochomorpha pallens, Pease,	x	x					
Trochomorpha Cressida, Gld.,	x						
Trochomorpha assimilis, Garr.,			x				
Patula modicella, Fer.,	x	x	x	x	x	x	x
Patula acuticosta, Mouss.,				x			
Patula lamellicosta, Garr.,	x						
Pitys Maupiensis, Garr.,							x
Pitys parvidens, Pse.,	x	x	x				
Pitys consobrina, Garr.,			x				
Pitys punctiperforata, Garr.,		x					
Pitys Boraborensis, Garr.,						x	
Libera bursatella, Gld.,	x						
Libera coarctata, Pfr.,		x					
Libera retunsa, Pse.,	x						
Libera Heynemanni, Pfr.,	x						
Libera gregaria, Garr.,		x					
Libera recedens, Garr.,		x					
Endodonta Huaheinensis, Pfr.,			x				
Endodonta ficta, Pse.,					x		
Endodonta fabrefacta, Pse.,				x	x		
Endodonta obolus, Gld.,			x	x			
Endodonta cretacea, Garr.,						x	
Endodonta Taneæ, Garr.,						x	x
Stenogyra Tuckeri, Pfr.,	x	x	x	x	x	x	x
Partula Otaheitana, Brug.,	x						
Partula filosa, Pfr.,	x						
Partula hyalina, Brod.,	x						
Partula clara, Pse.,	x						
Partula producta, Pse.,	x						
Partula nodosa, Pfr.,	x						
Partula stolida, Pse.,	x						
Partula attenuata, Pse.,	x			x			
Partula lineata, Less.,		x					

	Tahiti.	Moorea.	Huaheine.	Raiatea.	Tahaa.	Borabora.	Maupiti.
Partula elongata, Pse.,		x					
Partula tæniata, Mörch,		x					
Partula Mooreana, Hart.,		x					
Partula rosea, Brod.,			x				
Partula varia, Brod.,			x				
Partula arguta, Pse.,			x				
Partula annectens, Pse.,			x				
Partula faba, Mart.,				x	x		
Partula auriculata, Brod.,				x			
Partula turgida, Pse.,				x			
Partula radiata, Pse.,				x			
Partula compacta, Pse.,				x			
Partula callifera, Pfr.,				x			
Partula Thalia, Garr.,				x			
Partula Garrettii, Pse.,				x			
Partula citrina, Pse.,				x			
Partula dentifera, Pfr.,				x			
Partula Hebe, Pfr.,				x			
Partula fusca, Pse.,				x			
Partula navigatoria, Pfr.,				x			
Partula imperforata, Pse.,				x			
Partula rustica, Pse.,				x			
Partula vittata, Pse.,				x			
Partula crassilabris, Pse ,				x			
Partula formosa, Pse.,				x			
Partula lugubris, Pse.,				x			
Partula planilabrum, Pse.,					x		
Partula bilineata, Pse.,					x		
Partula virginea, Pse.,					x		
Partula umbilicata, Pse.,					x		
Partula lutea, Less.,						x	
Tornatellina Philippii, Pfr.,	x	x	x	x	x	x	x
Tornatellina oblonga, Pse.,	x	x	x	x	x	x	x
Tornatellina simplex, Pse.,	x	x	x	x	x	x	x
Tornatellina conica, Mouss.,	x	x	x	x	x	x	x
Tornatellina perplexa, Garr.,	x	x	x	x	x	x	x
Tornatellina serrata, Pse.,	x	x	x	x	x	x	x
Tornatellina nitida, Pse.,	x	x	x	x	x	x	x
Tornatellina aperta, Pse.,	x	x	x	x	x	x	x
Tornatellina Peaseana, Garr.,		x					
Vertigo pediculus, Shutt.,	x	x	x	x	x	x	x
Vertigo tantilla, Gld.,	x		x			x	x
Succinea humerosa, Gld.,	x						
Succinea costulosa, Pse.,	x						
Succinea subglobosa, Garr.,	x						
Succinea pudorina, Gld.,	x	x					
Succinea infundibuliformis, Gld.,	x						
Succinea Taheitensis, Pfr.,			x				
Succinea pallida, Pfr.,				x	x		
Succinea papillata, Pfr.,				x			
Limax Rarotonganus, Heyn.,	x						
Melampus luteus, Quoy and Gaimard,	x	x	x	x	x	x	x
Melampus Philippii, Kust.,	x	x	x	x	x	x	x
Melampus fasciatus, Desh.,	x	x	x	x	x	x	x

	Tahiti.	Moorea.	Huaheine.	Raiatea.	Tahaa.	Borabora.	Maupiti.
Melampus caffer, Kust.,	x	x	x	x	x	x	x
Melampus striatus, Pse.,	x		x				
Laimodonta conica, Pse.,						x	
Plecotrema mordax, Dohrn,	x						
Diadema biangulata, Pse.,		x					
Omphalotropis scitula, Gld.,	x	x					
Omphalotropis terebralis, Gld.,	x	x				x	
Omphalotropis Huaheinensis, Pfr.,		x	x	x			
Omphalotropis producta, Pse.,				x	x		
Omphalotropis oblonga, Pfr.,		x					
Omphalotropis Boraborensis, Dohrn,						x	
Atropis abbreviata, Pse.,	x						
Atropis Vescoi, Dohrn,	x						
Atropis obesa, Garr.,	x						
Atropis Bythinellæformis, Garr.,	x	x					
Atropis viridescens, Pse ,			x	x			
Scalinella Taheitensis, Pse.,			x				
Scalinella costata, Pse.,				x			
Scalinella Moussoni, O. Semp.,							x
Helicina albolabris, H. and J.,	x						
Helicina simulans, Garr.,	x						
Helicina minuta, Sowb.,	x	x					
Helicina flavescens, Pse.,	x	x	x	x	x	x	x
Helicina rustica, Pfr.,	x	x	x	x	x	x	x
Helicina inconspicua, Pfr.,	x	x	x	x	x	x	x
Helicina Maugeriæ, Gray,				x	x		
Helicina corrugata, Pse.,				x			
Helicina discoidea, Pse.,					x		
Helicina subrufa, Pse.,				x		x	
Helicina faba, Pse.,		x		x			
Helicina Raiatensis, Garr.,				x			
Chondrella parva, Pse.,	x	x	x	x	x	x	x
Chondrella striata, Pse.,	x	x	x	x	x	x	x
Chondrella insularis, Crosse,	x	x					
Taheitea pallida, Pse.,	x	x	x	x	x	x	x
Taheitea porrecta, Gld.,	x						
Assiminea nitida, Pse.,	x	x	x	x	x	x	x
	64	51	42	61	38	34	29

Tahiti, 64 species, 22 peculiar.
Moorea, 51 species, 11 peculiar.
Huaheine, 42 species, 10 peculiar.
Raiatea, 61 species, 23 peculiar.
Tahaa, 38 species, 8 peculiar.
Borabora, 34 species, 4 peculiar.
Maupiti, 29 species, 2 peculiar.

Out of the 139 species collected by the writer, 108 are peculiar to the group. They are all embraced in 25 genera, 7 of which are operculated. The excessive preponderance of indigenous species in the archipelago clearly demonstrates its claims to a special land-shell fauna.

With the exception of the species of *Melampus* and *Partula hyalina*, all the land shells which are common to other groups are invariably small species. *Mycrocystis conula* and *M. Discordiæ* are common to the Cook's, and the latter also occurs in the Marquesas Islands. *M. calculosa* is found in the latter group and the Viti Islands. *Stenogyra Tuckeri* and *Vertigo pediculus* are diffused throughout Polynesia. *Vertigo tantilla* inhabits the Cook's, Samoa and Viti Islands. *Tornatellina aperta* occurs in the Marquesas. *T. Philippii* extends its range to the Austral, Cook's and Marquesas. *T. conica*, *oblonga* and *nitida* live on all the south Polynesian groups; and *T. serrata*, together with *oblonga*, also occur in the Kingsmill and Caroline Islands. *T. perplexa* inhabits all the southeastern groups. *Partula hyalina* is common to the Austral and Mangaia, one of the Cook's Islands. *Patula modicella* ranges from the Paumotu to the Ellice's group. *Limax Raratonganus* inhabits the Cook's and probably the Gambier Is. *Chondrella parva* is common to the Marquesas, and *C. insularis* occurs in the Gambier group. *C. striata* is abundant in the Austral and Cook's Islands. *Helicina minuta* is found in the Austral, and *H. flavescens* in the Cook's group. *Assiminea nitida* ranges from the Paumotu to the Viti Islands. *Plecotrema mordax* occurs in the Paumotu, and I think inhabits the Gambier Islands. *Laimodonta conica* ranges from the Paumotu to the Cook's, and occurs on the islands in central Pacific. All the *Melampi*, except *striatus*, have a more or less wide range.

The following species, unknown to the writer, are accredited to the Society Islands:—

Helix oceanica, Le Guillou. "Taiti." Is a *Libera* and probably = *L. Heynemanni*. No mention is made of internal lamella

Helix Jacquinoti, Pfeiffer. "Tahiti" and "Marquesas." In his Mon. Hel., vii, he quotes "Taheita" only. It is a *Libera* with the peculiar sculpture of *L. fratercula*, and probably inhabits the Austral Islands.

Helix depressiformis, Pease. "Tahiti." May be a *Zonites*.

Succinea procera, Gould. "Eimeo" = Moorea. Possibly a large elongate form of the variable *S. pudorina*.

Succinea Bernardii, Recluz. "Oceania" (Recluz); "Tahiti" (Cuming).

Cyclostoma ventricosa, Hombron and Jacquinot. "Taheiti." Pfeiffer quotes the "Marquesas." Should be compared with *Atropis viridescens*.

Hydrocena Scherzeri, Zelebor. "Tahiti." Is, I think, a variety of *Omphalotropis scitula*.

Helicina Kusteriana, Pfeiffer. "Tahiti." I doubt this and the following being Tahitian species.

Helicina bicolor, Pfeiffer. "Tahiti."

Auricula viola, Lesson. "Borabora."

In addition to the species unknown to me, I may mention the following *Partulæ:*

P. compressa, Pfeiffer. "Society Islands." Referred by Carpenter to *P. radiata.* Dr. Hartman records it as a distinct species inhabiting the "Fiji Islands" = Viti Isles.

P. solidula, Reeve. "Society Islands." Referred by Carpenter to *P. virginea*, and by Dr. Hartman to *P. lutea.* This and the following are undoubtedly synonymous with some of the species recorded in this paper.

P. simplaria, Morelet. "Tahiti" Referred by Mousson to *P. varia*, and by Dr. Hartman to *P. rosea.*

P. Erhelii, Morelet. "Morea, Society Islands." Dr. Hartman thinks this will prove to be one of the forms of *P. tæniata.*

P. stenostoma, Pfeiffer. "Habitat. . . . ?" Dr. Hartman refers it to *P. vexillum* = *lineata.*

P. suturalis, Pfeiffer. "Habitat. . . . ?" Referred by Dr. Hartman to *P. strigosa* = *lineata*, var.

EXPLANATION OF PLATES.

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13.	" acuticosta Mouss.,	30
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15.	" subtilis Garr.,	31
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21.	" simplex Pse.,	82
22.	" serrata Pse.,	82
23.	" perplexa Garr.,	82
24.	" nitida Pse.,	83
25.	Endodonta ficta, Pse.,	38
26.	" Huahinensis Pfr.,	37
27.	" cretacea Garr.,	41
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THE TERTIARY GEOLOGY OF THE EASTERN AND SOUTHERN UNITED STATES.

By Professor Angelo Heilprin.

The United States Border Tertiaries and their European Equivalents.

The marine Tertiary deposits of the eastern United States occupy the outermost border (barring the post-Tertiary formations) of the Atlantic slope in a continuous extent from the neighborhood of Long Branch, N. J., to near, or quite to, the extremity of the peninsula of Florida. Beds referable to the same geological period have been identified on Martha's Vineyard, Mass., and good grounds exist for the supposition that similar beds extend beneath the water surface between this island and the New Jersey coast, and further to the northward. On the Gulf border the Tertiary deposits extend continuously through the States of Florida, Georgia, Alabama, Mississippi and Louisiana to a point on the Rio Grande in Texas at least (if not considerably more than) 60 miles N. W. of Laredo. Tennessee, Kentucky, Illinois and Missouri likewise contribute to the Tertiary area, while about one-half of the State of Arkansas is occupied by deposits of this age. On the Atlantic border the inner boundary line is removed from the coast by from about 25 miles, at a point opposite Trenton, to 160 miles in Georgia (near Macon). The deposits on the Gulf slope occupying the Mississippi embayment extend northward from the Gulf fully seven degrees, or about 500 miles, or nearly half way to the Canadian boundary line in Wisconsin.

The beds composing these deposits are in the north largely in the form of loose sands, clays, and marls, but in the south solid rock—shelly limestones, "buhrstone"—enters largely into their composition, more particularly of the older series. The dip on the Atlantic border, as also in Texas, Louisiana and Arkansas, is uniformly towards the S. E.; more nearly S. in Georgia, and S. by W. over a considerable portion of Alabama and Mississippi. Regarding the same in Florida little has been accurately determined. No disturbances of any moment appear to have intervened between the period of the deposition of the oldest member and the present day. In New Jersey, Delaware and Maryland, and again in Alabama, Mississippi, Tennessee, Arkansas and Texas, the deposits abut wholly or in part against those of the Cretaceous period (Sennonian and Mæstrichtian)—lying in some instances conformably upon them—while in some of the other States these last are completely (or nearly so) overlaid by them.

As to the ages indicated by the different members constituting the entire marine

Tertiary series, it may be premised at the outset that unequivocal representatives of both Eocene and Miocene exist; scarcely less positive is the existence of Oligocene deposits, whereas no satisfactory evidence has as yet been adduced proving the presence of Pliocene on our coast. The starting point in the correlation of the Eocenes is afforded by the well-known shell-sand layer of Claiborne, Ala., whose equivalency, at least in part, with the Calcaire Grossier of the Paris basin (Parisian), has long been recognized. The general similarity and identity existing between the fossil remains of the two localities here indicated place this determination beyond question. Beds representing the true "Claibornian" have been recognized in South Carolina, Georgia, Alabama, Mississippi and Texas, and doubtless some of the Eocene deposits in Arkansas and North Carolina belong to the same period. Underlying the "Claibornian" in the south are a series of clays, sands, and lignites, or in other localities, more or less siliceous and impure shelly limestones known as buhrstones—the "chalk hills"—several hundred feet in thickness, whose exact equivalence it is not as easy to demonstrate as those of the overlying sand beds, but which appear to hold a position somewhat parallel to that of the London clay (Londonian), or to the upper (and lower?) Suessonian of France. The "Buhrstone" (Siliceous Claiborne of Hilgard) occupies a considerable portion of the southern Tertiary area, attaining its principal development in Alabama, Georgia and South Carolina. In Alabama and Mississippi, as best studied in those States, with a probable development of 200–300 or more feet, we find at the base of the Eocene, a series of interstratified clays, sands and lignites, my "Eo-Lignitic," which seem to represent the most ancient of our cis-Mississippi Tertiary deposits. It appears probable that the oldest Eocene deposits occurring in New Jersey—those, for example, exposed on Shark River—belong here, and possibly also the Piscataway and Marlborough beds of Maryland and the Pamunkey sands of Virginia, which I have claimed to be the probable equivalents either of the British Thanet sands (or those of Bracheux, France), or of the British Bognor rock (lower Londonian). Not impossibly, however, they may prove to be the equivalents of a portion of the "Buhrstone." Immediately overlying the "Claibornian" in Alabama, Mississippi and South Carolina, with a considerable development in Louisiana and Georgia, and evidently also, although not as yet distinctly marked out, in Texas and Arkansas, are the deposits that have been designated the "Jacksonian," so named from the town of Jackson, in Mississippi, whence the fossils considered typical of this group were first obtained. In this series are included the so-called "white limestones" of many geologists, in which (and elsewhere) have been found, more or less abundantly, the remains of the Zeuglodon, the most distinctive fossil of the formation. No precise comparison between the fossils of this formation and those of correspondingly situated trans-Atlantic formations has as yet been instituted, and, therefore, it may perhaps be premature to assert with positiveness what the exact horizon represented by them may be. But as the beds occupy a position immediately overlying what is generally considered to be the next highest member of the typical European Eocene, as developed in the British and Paris basins, and underlying what can, I believe, be proved to be true Oligocene deposits, it may be reasonably inferred that they represent what in the basins referred to constitute the uppermost member of the entire series—the sands of Beauchamp and the Barton clay (= Upper Bagshot sands?). Confirmation of this view is afforded by the discovery in the Barton clay of Hampshire of the remains of a Zeuglodon (*Z. Wanklyni*, Seeley),* the only individual of the genus that has hitherto been found in any European formation. No really satisfactory evidence as yet exists as to the occurrence of Zeuglodon in any American formation but the "Jacksonian."

The so-called Oligocene deposits, to which reference has just been made, occupy in Alabama, Mississippi and Louisiana a narrow band of territory immediately to the south of, and bordering the "Jacksonian," which, as already stated, they also overlie. They occupy the greater portion of Florida, and doubtless also have a considerable development in southern Georgia and southeastern Texas, but in these last two States their areas have not as yet been accurately determined. They were originally called by Conrad, who first characterized them, the Vicksburg beds, and by me have been designated the "Orbitoitic," from the great abundance of *Orbitoides Mantelli*, their most distinctive fossil. Conrad referred the deposits in question to the Oligocene age not because they contained fossils in any way indicative of deposits of the same age in other countries, but merely for the reason that their contained fossils, as he supposed, were almost entirely distinct from those of the subjacent Eocene deposits, and equally distinct from those characteristic of the formations which he correctly surmised to be of newer date—the Atlantic Miocenes. This inference, I believe, can now much more satisfactorily be shown to be true. The *Orbitoides Mantelli* occurs in very considerable abundance in several of the West India Islands—Jamaica, Antigua, Trinidad—where the beds containing them are doubtless of equivalent age, and of the same age as the orbitoitic beds of Florida, and other of the southern States.† In the island of Trinidad they enter largely into the composition of the San Fernando rocks, which are by Guppy considered to represent the base of the Tertiary series of the islands, and which, together with the Chert formation in Antigua and the Anguilla beds, constitute a portion of his lower West Indian Miocene (in distinction to the principal Tertiary deposits of the island of Jamaica, the middle Tertiaries of San Domingo and Cuba, those of Cumaná, and the Caroni beds of Trinidad, which together form the upper or later part of the West Indian Miocene).‡ These San Fernando beds have been more recently correlated by Duncan with the deposits occurring on the island of St. Bartholomew, which are emphatically stated to be of pre-Miocene age, and where no Miocene deposits have thus far been discovered to exist.§

* Q. J. Geol. Soc., xxxii, p. 428.

† The species is also found in abundance in the lower limestone deposits of the island of Malta (T. R. Jones), in New Zealand (Karrer), and in Sinde, India (Carpenter).

‡ Q. J. Geol. Soc., xxii, p. 282, 1866.

§ Q. J. Geol. Soc., xxix, pp. 549–50, 1873.

The fossil coral fauna of this island is closely related to that of well-known Oligocene localities in Italy, as the Crosara and Castel Gomberto district, whose position in the geological scale they undoubtedly represent. This relationship is indicated by Duncan and other authors, and the writer is informed to the same effect by letter from Prof. Edward Suess, of Vienna, one of the profoundest workers in the field of the Tertiaries. The same eminent authority informs me that the Vicenza deposits above indicated are the unquestionable equivalents of the sands of Fontainebleau and of the marine Oligocene sands of the Mayence basin, and we thus have the parallelism established between our Vicksburg or orbitoitic beds and those of the typical Oligocene of southern Europe. The *Orbitoides Mantelli*, as already stated, also abounds in the lower limestone layer of the island of Malta,* and this layer has likewise been identified to be of Oligocene age, and to represent a part of the "Bormidian" of Sismonda, the older marine molasse of Bavaria and Switzerland, and probably also the Sotzka beds of the Vienna basin.† The relationship existing between the Florida orbitoitic rock and the deposits in some of the West India Islands which have been referred to the true Oligocene, is shown, irrespective of the great development of *Orbitoides Mantelli*, in the general character of the associated foraminiferal fauna. Thus we have in some places a sufficient abundance of *Operculinæ* (*Cristellaria rotella* of Conrad) and *Nummulinæ*,‡ and of species only doubtfully distinct from those found in Antigua, Trinidad or Jamaica. One or two other species of *Orbitoides* also occur, one very much of the *O. dispansus* type, and the other severely recalling *O. ephippium*. A further relationship with the equivalent St. Bartholomew deposits is established by the presence of at least two of the distinctive echinoids described from that island by Cotteau §—*Euspatangus Clevei* and *E. Antillarum*—and doubtless other identical forms will be found.

No unequivocal deposits of Miocene age have thus far been detected on the Gulf slope, although strong grounds exist for the supposition that the formation designated by Hilgard as the "Grand Gulf Group" belongs to this period of geological time, but to which division or horizon of the same, it is as yet impossible to state. On the Atlantic border the Miocene extends through the States of New Jersey, Delaware, Maryland, Virginia, North and South Carolina, and Georgia, following in a general way the trend of the Eocene, and, where not completely overlapping this last, lying between it and the coast. In North and South Carolina, also elsewhere, it is very largely obscured by deposits of post-Pliocene age. A patch of Miocene has been determined in the peninsula of Florida, near Rock Spring, in Orange Co., and not improbably a more or less continuous strip will be found to extend to this point southward from the

* Geol. Mag., i, p. 104, 1864.

† Fuchs, Sitzungsb. K. K. Acad. Wissen. of Vienna, lxx, i, p. 92, 1874; see also Hoernes, Jahrb. K. K. Geol. Reichs., xxviii, pp. 30–36, 1878.

‡ Heilprin, Proc. A. N. Sciences of Philadelphia, July, 1882.

§ K. Svens. Vet.-Akad. Handl., 1874.

Georgia line, and possibly much further. A slight unconformability has in some places been detected between the Miocene and the Eocene. In a paper entitled "On the Relative Ages and Classification of the post-Eocene Tertiary Deposits of the Atlantic Slope"* I have given what I considered to be good reasons for concluding that the Miocene deposits of North and South Carolina, my "Carolinian," were of newer date than those of Virginia and Maryland, and that not improbably they represented the deposits of the lower ("Black") Antwerp crag, the Diestian of the Belgian geologists, although the percentage of recent forms is considerably higher in this last than that which has been shown to be the case with the Carolinian fauna. The Virginia and Maryland deposits, on the other hand, and doubtless with these also those occurring in Delaware and New Jersey, represent approximately the "Mediterranean" series of the Austrian geologists, and in their two divisions, the "Marylandian" (or older deposits of Maryland, and probably also the lower bed in Virginia) and "Virginian" (as developed in the typical Miocene area of Virginia, and in the upper Maryland series) we have the correspondents, at least in part, of the "First Mediterranean" (and the faluns of Léognan and Saucats), and the "Second Mediterranean" (and the faluns of Touraine) respectively. The southeast corner of Virginia, with the towns of Norfolk, Portsmouth, Suffolk, etc., appears to belong to the "Carolinian" horizon, or that of North and South Carolina. Comparing the Atlantic Miocene with deposits referred to the same age as occurring on some of the West Indies, Trinidad and San Domingo for example, we find that out of ten species of mollusca obtained from the Caroni beds of the first named island, Guppy identified no less than six as identical with forms found in the eastern United States: *Petaloconchus sculpturatus*, *Dosinia acetabulum*, *Tellina biplicata*, *Pecten comparilis*, *Ostrea Virginica*, and *Teredo fistula*.† This number is about equally distributed between the States of North and South Carolina and Virginia, and hence no absolute indication (by comparison) of the horizon is afforded by their presence. *Petaloconchus sculpturatus*, *Teredo fistula* and *Tellina biplicata* are also found in the Miocene of San Domingo, and with them *Chama arcinella* and *Arca pexata*,‡ but most of the species occurring here are described as being distinct from North American forms. Further investigation, however, will doubtless reveal a greater number of identical forms. While, therefore, it is still impossible from paleontological data to establish a strict correlation between the Caribbean and Atlantic Miocenes, yet probably we will not be far from the truth in assuming that the former represent a part of the Virginian or Marylandian series, seeing that the percentage of living forms in the contained fauna is only 20, or possibly still lower (8 or 9, according to Carrick Moore).§ They would, therefore, correspond to some part of the "Mediterranean" as well.

* Proc. Acad. Nat. Sciences of Phila., June, 1882.
† Q. J. Geol. Soc., xxii, p. 576, 1866.
‡ Guppy, Q. J. Geol. Soc., xxii, p. 577.
§ Guppy, *op. cit.*, p. 575.

From what has preceded, the following table of the Atlantic and Gulf Tertiaries may be constructed:—

			Foreign Equivalents.
POST-PLIOCENE.			
PLIOCENE.	?	?	
MIOCENE.	CAROLINIAN. (Upper Atlantic Miocene.)	Deposits of North and South Carolina ("Sumpter" epoch of Dana).	Diestian?
	VIRGINIAN. (Middle Atlantic Miocene.)	Deposits of Virginia, and the newer group in Maryland ("Yorktown" epoch, in part, of Dana).	Probably of the age of the "Second Mediterranean" of the Austrian geologists, and of the faluns of Touraine; Caroni beds of Trinidad; and Miocene of San Domingo, Jamaica and Cumaná?
	MARYLANDIAN. (Lower Atlantic Miocene.)	Older Miocene deposits of Maryland, and possibly the lower beds in Virginia ("Yorktown" epoch, in part, of Dana).	Probably (or at least partially) the equivalent of the "First Mediterranean" of the Austrian geologists, and of the faluns of Léognan and Saucats.
OLIGOCENE.	ORBITOITIC.	Strata characterized by species of *Orbitoides*. Vicksburg beds, Florida nummulitic beds, etc.	Aquitanian. Deposits of Crosara and Castel Gomberto (Vicentin), Oligocene of the Mayence basin, sands of Fontainebleau, lower limestone of Malta, Fernando beds on Trinidad, Antigua, Chert, St. Bartholomew Oligocene.
EOCENE.	JACKSONIAN.	Jackson beds of Mississippi. "White Limestone" of Alabama.	Barton Clay (Bartonian). Sands of Beauchamp?
	CLAIBORNIAN.	Fossiliferous arenaceous deposit of Claiborne, Ala., etc.	Age of the "Calcaire Grossier" of France (Parisian).
	BUHRSTONE.	Beds below the true Claibornian on the Alabama River, "Chalk Hills" of the southern part of the State, etc. "Siliceous Claiborne" (Hilgard) of Mississippi. Maryland Eocene, in part?	Londonian?
	EO-LIGNITIC.	Lignite, sands and clays situated at the base of the Tertiary series in Alabama, etc. Marlborough and Piscataway beds of Maryland? Shark River deposits of New Jersey.	Thanetian? Bognor rock?

New Jersey.

The deposits of the Tertiary formations in this State follow in a general parallel course the trend of the next older or Cretaceous deposits (Mæstrichtian and Sennonian), upon which they can be shown in some places to lie conformably, or very nearly so.

Their inner border may be said to correspond in a general way with a S. W.–N. E. line connecting Long Branch, on the Atlantic coast, with a point on the Delaware River, situated almost due west of the city of Salem, or opposite Delaware City in the State of Delaware.* The surface embraced between the sea-border and this line comprises between one-third and one-half the area of the entire State, and presents in its physical features the characters of gravelly sands and clays.

EOCENE.—There can be no question but that the deposits of this period, forming part of the "Upper Marl Bed," so called, which appear along Deal Beach on the Atlantic coast, on Shark River, in isolated patches about Farmingdale, Squankum, and elsewhere, and in a more or less continuous belt from near New Egypt to Clementon, represent in part, if not in whole, approximately the lowest of the entire Eocene series occurring in the eastern United States. Their chronological equivalence with the oldest Tertiary beds occurring in some of the other States—as the Piscataway beds of Maryland, and the lower beds exposed on Bashia Creek, Clarke Co., Ala.—has not yet been definitely made out, but the evidence that has thus far been adduced is sufficiently strong in support of Conrad's original surmise as to the existence of such equivalence (Proc. Acad. Nat. Sciences of Philadelphia, 1865, p. 71; Smithsonian Misc. Coll., 200, 1866, p. 1). The fossils occurring in the New Jersey strata are mainly in the form of casts, and their precise determination is consequently involved in a considerable amount of uncertainty. It appears sufficiently clear, however, that many, if not most, of the forms are such as have not yet been found in the other States, although they represent distinctly Eocene types, but which approximate very closely certain trans-Atlantic species.

Those (invertebrate) specifically determined are, according to Conrad, the following:

Nautilus (*Aturia*) *Vanuxemi*, Conr.
Nautilus (*Cymomia*) *Burtini*, Nyst.
Nautilus (*Cymomia*) *Lamarckii*, Desh.
? *Rostellaria* (*Hippochrenes*) *columbaria*, Desh.
? *Voluta* (*Volutilithes*) *mutata*, Desh.
Pleurotoma (*Surcula*) *annosa*, Conr.
? *Pyrula* (*Pyrificus*) *Smithii*, Sow.
Pleurotomaria perlata, Conr.
Architectonica idonea, Conr.
? *Onustus* (*Phorus*) *extensus*, Sow.
Actæonema prisca, Conr.
Thracia modesta.
Caryatis Delawarensis, Gabb.
Protocardia curta, Conr.
Crassatella littoralis, Conr.
Venericardia perantiqua, Conr.
Yoldia protexta, Conr.
Avicula annosa, Conr.

(Cook, Geology of New Jersey, 1868, pp. 731–2; Check List of Eocene Fossils, Smiths. Misc. Coll., 1866.)

To these are sometimes, but erroneously, added *Arca quindecemradiata*, Gabb, *Crassatella Delawarensis*, Gabb, and *Terebratula glossa*, Conr.

It will thus be seen that the most distinctive Eocene forms found elsewhere, such as *Ostrea sellæformis*, *Ostrea compressirostra* (= *O. Bellovacina*?), *Cucullæa gigantea*,

* Geological Map of New Jersey, 1882. Prepared by the Geological Survey of the State, under the direction of Prof. G. H. Cook.

or *Cardita planicosta*, have not yet been discovered in this State. While, therefore, from paleontological evidence alone it would be impossible to indicate with precision the horizon which the New Jersey deposits hold relatively to the other Eocene deposits of the Atlantic and Gulf borders of the United States, yet from the presence of a number of organic forms which would appear to be indicative rather of an older than of a newer period, the absence of distinctively Upper Eocene species, and the circumstance that the beds in question occupy a position directly in line with the similarly placed older Tertiary deposits of Maryland and Virginia, whose age has been more definitely fixed (Thanetian ?), it may safely be premised that the horizon is near the base of the entire Eocene series.

MIOCENE.—Whatever may be the exact nature or age of some of the superficial deposits, as the "glass sands," occupying that portion of the State lying between the Eocene line and the coast, there can be little or no doubt existing as to the direct continuity throughout that portion of the State of the strata that have in Maryland and Virginia been designated the Miocene. Beds referable to this period have been identified in numerous areas throughout the region, and have in various localities been described as lying unconformably upon the Eocene, *i. e.*, with a less pronounced dip toward the sea. The fossils hitherto discovered in the deposits of this period are comparatively few in number, and have been obtained in principal part from the southern sections of the State, from the marl exposures in Salem and Cumberland (Shiloh) Counties.

Among the forms that have been identified with species occurring in other Miocene localities are:—

Ostrea Virginica (including *O. Mauricensis*).
Pecten Humphreysii.
? *Mytilus inflatus.*
? *Astarte exaltata* (*A. Thomasii*).
Astarte undulata (*A. distans*).
Crassatella melina.
Carditamera arata.
Yoldia limatula.
Corbula elevata.
Natica catenoides.

Other species, apparently confined to the State, are:—

Ostrea percrassa.
Plicatula densata.
Carditamera aculeata.
Mysia parilis.
Venus Ducatellii.
Venus plena.
Mercenaria cancellata, Gabb.
Tellina Shilohensis.
Thracia myæformis.
Anatina alta.
Saxicava (?) *parilis.*
Fasciolaria (*Turbinella ?*) *Woodii.*
Fulgur scalariformis.
Turritella æquistriata.
Turritella Cumberlandiana.
Turritella secta.
*Fissurella Griscomi.**

* Specimens of most of the species enumerated in the above lists are in the possession of the Academy of Natural Sciences.

It is very likely that both divisions of the Miocene indicated by me as occurring in Maryland and Virginia,* and by me designated as the "Marylandian" and "Virginian," or the lower and middle Atlantic Miocenes respectively,† will eventually be found to be equally well marked off in New Jersey, although up to the present time, from the sparseness of the fossil remains that have been collected, no such subdivision could be satisfactorily attempted. But from what material we have at hand, it may be safely asserted that the localities which have been so assiduously searched in the neighborhood of Shiloh, and elsewhere in Salem and Cumberland Counties, belong to the older or "Marylandian" division.‡

No satisfactory evidence has yet been brought forward proving the existence of any marine Pliocene deposits in the State.

Delaware.

We possess but very little precise information respecting the Tertiary formations of this State; no really accurate survey has here ever been carried into effect, and our present geological and paleontological knowledge of the region is based largely upon the "Memoir of the Geological Survey of the State of Delaware," of Prof. J. C. Booth, published in 1841. I am not aware that the Eocene formation has been absolutely identified by its fossil remains as occurring in the State, but no reasonable doubt can be entertained as to its existence there (although possibly entirely obscured by the newer Miocene deposits) as a direct continuation of, or connection between, the belts developed in Maryland and New Jersey. The northern boundary of the formation, corresponding to the southern boundary of the parallelly trending Cretaceous formation, will be found to lie along and somewhat to the north of the Appoquinimink, holding, probably, a more or less S. W.–N. E. direction. The southern third of the State appears to be in principal part covered by either very late Tertiary, or, what seems more likely, by post-Tertiary deposits; these are described as occupying the whole of Sussex County and the southern portion of Kent, defining the southern limit of the Miocene along the Murderkill and its tributaries. Prof. Booth recognizes two principal divisions in the Delaware Tertiaries, which he designates the northern and southern Tertiaries, but these have no special significance, being founded on purely geographical and lithological, and without reference to paleontological, characters. Still, more careful examination may prove them to correspond in a general way with the two Miocene divisions to which reference has already been made when treating of the geology of New Jersey. The invertebrate fossils specifically identified by Booth as occurring in the Miocene deposits are: *Venus alveata*, *Venus inocerami-*

* Proc. A. N. S., 1880, p. 20, *et seq.*; 1882, p. 150, *et seq.*

† Proc. A. N. S., 1882, p. 184.

‡ Heilprin: "On the Stratigraphical Evidence afforded by the Tertiary Fossils of the Peninsula of Maryland," Proc. A. N. S., 1880, pp. 31–2.

formis (*V. inoceroides*), *Nucula lævis*, *Myoconcha*, probably *M. incurva*, and *Pecten Madisonius*.

Maryland.

With respect to the Tertiary geology of this State we have very much more precise information than in the case of Delaware. although it must be confessed that a great deal still remains to be accomplished before an even approximately accurate delineation of boundary lines can be presented. This applies more particularly to the region of the East Shore, where the geological work done has been of a decidedly unsatisfactory character—a character that unfortunately only too well distinguishes the exploration of a very considerable portion of the Atlantic border. It is lamentable to find in the report of a survey published as late as 1860,* that work had not yet proceeded sufficiently far to permit of the subdivision of the Tertiary series into its primary component members (Eocene, Miocene and Pliocene), and this thirty years after the publication of Conrad's paper on the "Geology and Organic Remains of a Part of the Peninsula of Maryland"!†

The Cretaceo-Tertiary boundary line enters Kent County from Delaware at a point situated a few miles north of Millington, bisects in a southwesterly direction the peninsula formed between the northern head of Chesapeake Bay and Chester River, and continues on the west shore from a point a little outside of Annapolis to the neighborhood of Fort Washington, on the Potomac, a few miles below the city of Washington. South of this line to about the Little Choptank in Dorchester County, the region is occupied by the older and middle Tertiary deposits; the rest of the State southward and southeastward, consisting of loamy clays and sands, is considered to be of post-Tertiary date. The combined Tertiary and post-Tertiary areas cover nearly one-half of the entire State.

Eocene.—The development of this formation on the East Shore has thus far not been accurately traced, but it may be assumed that its southern boundary lies somewhat between Chester River and Centreville. Chestertown and Millington doubtless both lie within its area. On the West Shore the formation has been more accurately studied, at least from a paleontological standpoint, but even here the exact boundary line, separating it on the southeast from the adjoining Miocene, has never been accurately defined. It may be said to correspond in a general way with a N. E.–S. W. line, drawn from the inlet known as West River, on the Chesapeake, to the mouth of Port Tobacco River, on the Potomac. In the area occupied by this formation, which consists of clays, marls, indurated sands, and, in some places, compact siliceous rocks, fossil remains, although somewhat restricted in variety, are sufficiently abundant, and comprise a number of forms, prominent by size, which are more or less distinctive of

* First Report of Philip T. Tyson, State Agricultural Chemist, p. 43.
† Journ. A. N. S., vi, p. 205, *et seq.*

the State. The best known fossil-bearing localities are Fort Washington, situated a few miles below the city of Washington, Piscataway, on Piscataway Creek, and Upper Marlborough, in Prince George's County, which have been made known principally through the labors of Mr. Conrad.

The positive determination of the relation which these older Tertiary deposits hold to the typical American Eocene series as exhibited in Alabama, can only be arrived at when a direct stratigraphical continuity can be traced between the deposits of the two States, or between their previously recognized representatives in the intervening States. This is due to the fact that several members of the Eocene series appear to be absent from this portion of the Atlantic border, but exactly which it has as yet been impossible to determine. The presence of strata of Jacksonian age has never been detected, nor have we any positive knowledge concerning the existence in the State of any beds which may be looked upon as the equivalents of the Orbitoide limestone, although Oligocene (Vicksburgian) strata may exist along the Chesapeake. But whether the deposits in question—Fort Washington, Piscataway, and Upper Marlborough—represent the Claibornian, Buhrstone or Eo-Lignitic is a matter of considerable uncertainty, perhaps largely due to their comparatively feeble development. Almost the only evidence we have bearing upon this point is derived from the character of the contained fossils, but even here the results obtained are far from satisfactory, and for two reasons: in the first place, the character of the Eocene fossils is largely uniform throughout the greater portion of the entire series, as is shown by nearly the lowest and highest exposures in the State of Alabama; and in the second place, the great distance intervening between the two localities—Alabama and Maryland—may readily account for certain differences in the general aspect of the two fossil faunas, which otherwise would probably be attributable to a non-contemporaneity in the periods of their introduction. The evidence afforded by lithological characters is almost equally unsatisfactory, since there is a frequent repetition of the general rock aspect—greensands, clays, and siliceous marls—observable at different stages of the series. Conrad, the only investigator whose observations on this subject are of scientific value, affirms that the majority of the fossil mollusca are of the Claiborne type, and he consequently correlates the beds containing them in a general way with those exposed on the Alabama River, although without specially indicating with what portion of the Claiborne section they were supposed to correspond. Indeed, about the only fossils obtained from the Maryland localities which can in any way be said to be either characteristic of or peculiar to them are *Panopea elongata*, *Pholadomya Marylandica*, *Pholas petrosa*, *Cucullæa* (*Latiarca*) *gigantea*, *Ostrea compressirostra*, and one or two doubtful species of *Crassatella*. All the species here named, if we except the doubtful Crassatellas and *Ostrea compressirostra*, are good species, and if we further deduct *Cucullæa gigantea*, the only Eocene species of the genera to which they belong thus far discovered in the eastern or southern United States. On the whole, therefore, they afford little or no clue to the exact determination of the age of the deposits in which they occur. It is true that an examination of the homotaxial deposits of Europe shows the genera *Pholadomya* and *Panopea* to be more especially characteristic of the lower or even lowermost horizon, of the Eocene series, as in the English and French basins, but no special inference can be drawn from this circumstance, since the species are not the same, and the genera survived through the succeeding periods to the present day. In the case of *Ostrea compressirostra*, however, we have a much more tangible point. The species, first described and figured by Say (Journal of the Academy of Natural Sciences, iv, p. 133), is certainly very intimately related to the *Ostrea Bellovacina* of Lamarck, and apparently undistinguishable from certain varieties of that species.* Now this species, although not exclusively restricted to the lowest Eocene beds, is nevertheless highly characteristic of the Thanet sands, below the London Clay proper and also below what was formerly designated as the "Plastic Clay" series, where it constitutes a true basement accumulation; and it holds almost precisely the same relation to the beds of the Paris basin, where, according to Deshayes (*Animaux s. Vertèbres, Bassin de Paris*, ii, p. 117), it occupies the horizon of the Bracheux sands. The species, wherever found, appears to be considerably restricted in its vertical range, and its occurrence, therefore, in some of the American deposits would seem to afford some more decided indication of the true age of those deposits than could be obtained from the character of the limited number of its contained fossils taken as a whole. Associated with *Ostrea compressirostra* were found casts of the large *Cucullæa gigantea* (Conrad, Journ. Acad. Nat. Sciences, vi, p. 215, 1830), a species which appears not to be represented in any of the equivalent European formations. But in Virginia, in beds which can be shown to be the direct equivalents of those of Maryland, there occurs, in addition to the *C. gigantea* of Conrad, a second species of *Cucullæa*, the *C. onochela* of Rogers (Trans. Am. Philos. Soc., new ser., vi, p. 373; *Latiarca idonea*, Conr., Proc. Acad. Nat. Sci., 1872, p. 53—no locality stated), which, if not identical with the *C. crassatina* of Lamarck, from the Bracheux sands of the Paris basin, is certainly most intimately related to it, and can be considered in every way as its immediate representative.† It should also be stated that the only other species of *Cucullæa* described by Deshayes (*Animaux s. Vertèbr.*, *Bassin de Paris*, i, p. 109) from the Paris basin (*C. incerta*, Desh.) is found in the same horizon with the *C. crassatina*,

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* The distinguishing characters of the beaks pointed out by Say do not seem to hold in many instances, as is proved by specimens of the *C. Bellovacina* from the "London Clay" of Bognor, England, in the collections of the Academy, which do not differ as much from certain American specimens as these last do among themselves.

† I have had no specimens of the European species with which to institute direct comparisons, but as the species is a large one, and with well-defined characters, I have relied upon the figures and characters as furnished by Deshayes (*Coquilles Fossiles, Environs de Paris*, i, p. 193; Atlas, Pl. xxxi, figs. 8 and 9), which are well known for their accuracy. The *C. crassatina* is catalogued by Prestwich (Quart. Journ. Geol. Soc., 1854, p. 109) and Morris ("Cat. Brit. Foss.," p. 197) as being also an English form, and as belonging to the Thanet series, but by Searles Wood ("Monograph of the Eocene Mollusca" Bivalves, in Paleont. Soc. Publ., 1861, p. 94), the species occurring at Herne Bay, Faversham, etc., is considered to be distinct (*C. decussata*, Park.).

and, likewise, the single species described by Searles Wood from the older Tertiaries of England is a *lower* Eocene form.

If such comparisons are of any value stratigraphically we may fairly look upon the Maryland Eocene deposits—the Piscataway sands below, and the Marlborough rock above—as representing a horizon nearly equal to that of the Thanet sands of England and the Bracheux sands of the Paris basin, or of the British Bognor rock (= London Clay).* In either case they would be near the base of the Eocene series.

In the scale of the American series as exhibited in Alabama they would occupy a position probably near the base of the "Buhrstone," or possibly even lower, as the equivalents of the beds exposed on Bashia Creek, and Cave and Knight's Branches ("Eo-Lignitic").

Miocene.—All the rest of the State southeast of the Eocene line, except such parts as may be covered by post-Pliocene deposits—Worcester, Wicomico, and portions of Dorchester and St. Mary's Counties—belongs to the Miocene formation. As in the case of New Jersey, no satisfactory evidence has as yet been brought forward proving the existence in the State of the Pliocene.

In a former paper † I have attempted to show that the post-Eocene Tertiary deposits of this State are divisible into two groups—an older and a newer, one of which —the newer—is unequivocally Miocene, and the other, possibly, Oligocene; both belong to a period antedating the principal post-Eocene deposits of the States of North and South Carolina. The deposits of the older group, which I have since designated as the "Marylandian," ‡ and have recognized as constituting the Lower Atlantic Miocene of the American coast, are best exhibited in the oyster banks, rising a few feet above tide-water, in Anne Arundel County, along the western shore of the Chesapeake, in the exposure of Calvert Cliffs, and in the Perna beds of the Patuxent River near Benedict.

Localities of the newer group are found at or near Cove Point, Calvert County, the Patuxent River, below and above Benedict (in the deposits overlying the Perna beds), and at numerous points along the St. Mary's River, in St. Mary's County. The proportion of recent species in the fossil fauna is here very much higher than in the deposits of the older group, and clearly indicates a considerable interval between the periods of the respective depositions. Beds belonging to the newer period, which I have elsewhere correlated with the principal Miocene deposits of Virginia (the "Virginian"), also occur on the East Shore, at Easton, on the Choptank, where the molluscan fossil fauna corresponds very closely with that observed on the west bank of the Patuxent. Connecting the points where the two series of deposits occur, it will

* The similarity existing between the Marlborough and Bognor rocks has been pointed out by Conrad (Proc. National Institution, p. 172, 1841).

† Proc. A. N. S., 1880, p. 20, *et. seq.*

‡ "On the Relative Ages and Classification of the post-Eocene Tertiary Deposits of the Atlantic Slope," Proc. A. N. S., June, 1882.

be seen that the older group (Marylandian) occupies a northwestern area, or that adjoining the Eocene; and the newer group (Virginian) the area included between this last and that occupied by the post-Pliocene beds to the southeast.

At the time that I prepared the article above referred to on "The Stratigraphical Evidence afforded by the Tertiary Fossils of the Peninsula of Maryland," wherein I indicated the existence and positions of the two divisions of the Maryland "Medial Tertiary," I was unaware that Conrad, some forty-five years before, had arrived at conclusions approximately identical with my own (although the data supporting his position were of a rather fragmentary and not exactly satisfactory character), but which he appears to have completely ignored at a later day. Thus in a paper on the "Tertiary Strata of the Atlantic Coast," published in 1835,* it is stated that between the Chesapeake Bay and Potomac River two classes of deposits occur "besides the equivalent of the London Clay or Eocene, the first of which, lying most to the westward, contains fewer recent species than the other, and is well characterized by the gigantic *Perna maxillata*." In my paper already referred to I have also stated that the lower or older beds are those which are characterized by *Perna maxillata*,† and it is just this species which is likewise largely disseminated through well-known Oligocene and older Miocene deposits of Europe. With it occurs *Mytilus incurva*, a large mytiloid form, which may be taken to be the representative of the *Mytilus Haidingeri* or *M. Faujasi*, forms also distinctive of the European Oligocene and Miocene.

Virginia.

The Tertiary formations of this State, for whose delineation we are principally indebted to the labors of Prof. W. B. Rogers and Mr. Conrad, pursue a more nearly meridional direction than in any of the other States that we have thus far been considering. The region occupied by them, designated also as the "Tertiary marl region," has been defined by Rogers ‡ as embracing "nearly all that portion of the State included between its eastern boundary, the Chesapeake Bay and the Atlantic, and a hypothetical line intersecting the principal rivers at their lowest falls. Various beds of clay and sand, nearly horizontal in position, abounding in fossil shells, and the remains of large marine animals, form the characteristic strata of this division of the State, while occasional bands of iron ore, and beds of greensand, and a small portion of gypsum, occurring in connection with one of the fossiliferous deposits of the region, are among its other materials of value."

The inner boundary corresponds in a general way with a line passing from the mouth of Acquia Creek, on the Potomac, to the neighborhood (a little outside) of Fredericksburg, and thence through Wales, at the junction of the North and South

* Am. Journ. of Science and Arts, vol. xxviii, p. 106.

† "There is, further, strong, although not conclusive, evidence for considering the beds containing *Perna maxillata* and *Ostrea percrassa* as the lowest of the series." Proc. A. N. S., 1880, p. 23.

‡ Report of the Geological Reconnoissance of the State of Virginia, 1836, p. 8.

Anna Rivers, tributaries of the Pamunkey, Richmond and Petersburg to the North Carolina frontier. For a considerable distance south of Petersburg this line has not been accurately traced, but its course shows a southwesterly deflection.

Eocene.—From the line above indicated as forming the western boundary of the Tertiary in general the Eocene extends eastward in a narrow meridional strip, with a breadth varying from about 5 miles in the south to 12–15 miles in the north. On the west in its northern half it abuts upon the Trias, and in its southern half upon rocks of Archæan age. The absolute thickness of the formation appears nowhere to have been determined, and until more satisfactory data as to the amount of dip and the exact boundary outcrops be afforded, no reliable calculation can be made. But it would appear that in no locality where the beds are exposed does the visible development much exceed 30–40 feet. On the James River between Coggin's Point and City Point the thickness of the exposed strata is about 20 feet, and in the neighborhood of Mathias's Point, on the Potomac, opposite Port Tobacco in Maryland, which marks the eastern boundary of the formation, the thickness of the strata, as ascertained by Rogers, was very nearly the same, or 25 feet.

There is no reason for doubting that the Virginia Eocene deposits are a direct continuation of those of Maryland, as the position of the beds would readily suggest, and that consequently they represent an equivalent horizon. This conclusion is further borne out by the character of the fossil remains, which approximate closely to those of the State referred to, and among which we find such prominent large forms as *Ostrea compressirostra*,* *Cardita planicosta* (including *Venericardia ascia* of Rogers), *Turritella Mortoni*, *Cucullæa gigantea*, and the related *Cucullæa onochela* (Rogers; *Latiarca idonea* of Conrad), the last but doubtfully distinct from the *C. crassatina*, Lam., from the Bracheux sands of the Paris basin. The large saddle-shaped oyster (*Ostrea sellæformis*) which becomes such a prominent feature in the Eocene fauna of the more southern States, and one of whose deposits forms the basement layer in the famous Claiborne bluff on the Alabama River, appears to have had a much greater development here than in Maryland, where the remains of the species are very scanty.

Miocene.—The Miocene area extends from the Eocene boundary already defined to the sea, occupying what in principal part constitutes the tidal districts of the State. As in the case of the Eocene, there can be no question but that the deposits of this age form a direct continuation of the similar deposits of Maryland, and that consequently we have here approximately the same horizon or horizons represented. The

* Specimen in the possession of the Academy of Natural Sciences from near Alexandria, right bank of the Potomac. Conrad, in his list of the Eocene fossils prepared for the Smithsonian Institution in 1866, confines the species to Maryland exclusively. Rogers, in his reports published in the American Philosophical Transactions (new series, vols. v and vi), makes frequent reference to this fossil, but, singularly enough, credits it with a position in the Miocene. It is not unlikely that in some instances, at least, the *O. disparilis* may have been mistaken for the form in question, to which it bears a striking resemblance. Nor does it seem unlikely that the *O. sinuosa* is more nearly *O. disparilis* than *O. compressirostra*, although stated to come from the Eocene greensands (Rogers, vol. v, p. 340; vol. vi, Pl. xxvii, fig. 1).

division into the "lower" and "middle Atlantic Miocene," or what I have designated the "Marylandian" and "Virginian," does not, however, appear to be as distinctly marked off as in that State, the fossils indicating a more nearly uniform age (Virginian), but this seeming divergence may possibly be attributed to imperfect observation, or to a lack of observation. The discussion of the age of the beds here referred to, as well as of the equivalent deposits of Maryland, and their relations to the French faluns and the older Tertiary deposits of the Vienna basin, is fully set forth in my paper "On the Relative Ages and Classification of the post-Eocene Tertiary Deposits of the Atlantic Slope" (Proc. Acad. Nat. Sciences of Phila., June, 1882). It is not unlikely that the extremity of the State lying south of the James River, and including partly or wholly the counties of Southampton, Isle of Wight, Nansemond, Norfolk and Princess Anne (with the towns, among others, of Wakefield, Smithfield, Suffolk and Norfolk), as well as the extremities of the peninsulas included between the James, York and Rappahannock Rivers, belongs to a somewhat newer period than the region lying farther to the west, or more nearly that represented by the later Tertiary deposits of North and South Carolina—the "Carolinian" or upper Atlantic Miocene —whose continuation appears to be found here. The "fragmentary rock," consisting largely of comminuted and closely cemented shell fragments, described by Rogers * as occurring at various points on the eastern portion of the Miocene district, at Yorktown and Bellefield on the York River, and "near the extremity of all the peninsulas," and wherever occurring forming a distinctive feature in the stratigraphy of the region, is an indication of this newer formation. The existence of a newer division of the post-Eocene Tertiary in southeastern Virginia, although erroneously referred to the "Medial Pliocene," was already indicated by Conrad in 1835,† who assigned as localities for the same Yorktown, Suffolk and the James River near Smithfall (Smithfield?). A somewhat similar division of the Tertiary is made by Rogers, who, however, refers the newer division, with West Point, Norfolk, Suffolk, Wakefield, etc., to the Pliocene.‡

One of the most interesting components of the Virginia Miocene formation is the deposit of diatomaceous earth, with a development in some places of 30 feet, which is exposed near Richmond ("Richmond earth") and Petersburg, and which lies near the base of the system. It rests upon, or but little above the top of the Eocene, from which it is distinguished by the presence of occasional casts of Miocene shells, which clearly indicate its later origin. The same deposit has been traced to the Patuxent River and Herring Bay, on the Chesapeake, Md., and has been struck in an artesian boring at Fortress Monroe at a depth of 558 feet below the surface, likewise resting upon the Eocene.§ We have here direct evidence bearing upon the thickness of the

* Rep. Geol. Reconn., 1836, pp. 23–4.

† Am. Journ. Science and Arts, xxviii, p. 106.

‡ Macfarlane's "Geological Railway Guide," 1879, p. 184.

§ Rogers, in Macfarlane's Guide, p. 183.

Miocene deposits, and an indication of the dip of the underlying Eocene beds. If we assume with Rogers that the eastern outcrop of the Eocene formation above tide-water on a line west of Fortress Monroe is located at about the town of Waverly,* then we have for a horizontal distance of about 42 miles a descent of between 550 and 600 feet, or an average dip of 13–14 feet to the mile.†

North Carolina.

Most of the Tertiary deposits of this State are obscured by a capping of Quaternary gravel, sand and clay, which extends inwards for a distance of upwards of 100 miles from the sea. Beds belonging to both the Eocene and Miocene series occur in disconnected and limited patches, exposed principally in river excavations and bluffs. The exact horizon or horizons in the typical series which the Eocene beds represent, has not yet been satisfactorily ascertained, the paucity of fossil remains, and their divergence from the representative Eocene forms, preventing an absolute determination. The following list embraces most of the invertebrate forms, beyond indeterminable casts, that have been referred to the formation:—

Cidaris Mitchelii.
Cidaris Carolinensis.
Scutella Lyelli.
Mortonia (Periarchus) altus.
Microcrinus conoides.
Echinocyamus parvus.
Gonioclypeus subangulatus.
Flabellum (?) cuneiforme.
Dendrophyllia lævis.
Caryophyllia subdichotoma.
Lunulites contigua.
Lunulites sexangulata.
Lunulites distans.
Eschara tubulata.
Terebratula Wilmingtonensis.
Terebratula demissirostra.
Pecten membranacea.
Pecten anisopleura.
Pecten Carolinensis.
Nucula magnifica.
Lucina pandata.
Cardita rotunda.
Vivipara Lyelli.
Oliva Alabamensis.
Natica ætites.
Infundibulum trochiforme.‡

The Miocene clearly belongs to a period ulterior to the deposition of the principal Maryland and Virginia deposits, and represents approximately the South Carolina series ("Carolinian"). Owing to the superficial covering of Quaternary material it has been thus far impossible to determine with the desired precision the contour lines of the two formations, and hence on the accompanying map these (the inner boundaries) as represented must be considered as being largely hypothetical.

* "Lower 19 Tertiary here probably above tide-level," in Macfarlane, p. 184.

† Through the kindness of Dr. Guillou the writer has obtained specimens from an artesian boring conducted at Newport News (June, 1882), in which he has been able to recognize fragments of *Pecten Humphreysii*, a form characteristic of the lower Atlantic Miocene ("Marylandian") of Maryland. The depth indicated for the fragments was 410 feet.

‡ The non-italicized names are given on the authority of Lyell, Q. J. Geol. Soc., i, pp. 431–32.

The following descriptions are borrowed from Kerr's report on the geology of the State*:—

Eocene.—The distribution of the rocks of this subdivision is more limited than that of the Cretaceous, and much more so than that of the Miocene, which overlies it. The boundaries of it, north and south, are the Neuse and the Cape Fear; and it is found on the Neuse to within 2 or 3 miles of the railroad crossing, near Goldsboro', and at one point, in an isolated outcrop on the river bluff 7 or 8 miles further west; and it occurs in limited outcrops throughout the triangular region between Newbern and Goldsboro' and Wilmington. It consists of light-colored and yellowish consolidated marlites (bluffs of the Neuse 10 miles below Goldsboro', above Newbern, Natural Wells near Magnolia), shell conglomerates (about Newbern, Trent River), siliceous buhrstones, calcareous sandstone (near Goldsboro', Wilmington, etc.), gray and hard limestone, coarse conglomerates of worn shells, sharks' teeth, and fragments of bones and stony pebbles (upper part of Wilmington and at Rocky Point), or fine shaly, light-colored infusorial clays, as seen in Sampson County. Outside of the region bounded by the above points there are two or three patches of Eocene, one capping a hill 350 feet above the sea, on the railroad 7 miles east of Raleigh, a siliceous shell conglomerate of 2 or 3 acres in extent and 6 to 10 inches thick; the second, a ferruginous and calcareous sandstone of 4 or 5 feet thickness, on the top of a hill in the southeastern corner of Moore; this last containing some shells and many echinoderms. These fragments, or outliers, show that this formation, limited as it was in thickness, had a vastly greater horizontal extent than would have been suspected, and they carry the shores of the Eocene seas quite into the hill country of the State, and nearly 150 miles from the present coast line, and to an elevation of nearly 400 feet.

Miocene.—This subdivision of the Tertiary extends over nearly the whole seaboard region, from the sea-shore and the western margin of the sounds, 50 to 75 miles inland. It has a much greater horizontal extent than the preceding, and a greater thickness, but is less continuous, being found in disconnected patches, often of quite limited area, and exposed, like the preceding, only in river bluffs, ravines, ditches, wells, etc. It consists of beds of clay, sand and marl, which are locally filled with shells, more or less decayed, to a thickness of 2 or 3 to 6 or 8 feet, and occasionally 10 or 20. The formation thickens, deepens toward the northern border of the State, the beds being much thicker on the Tar and Roanoke than on the rivers south of them, and in fact being of such thickness here as to conceal both the Eocene, if it exists, and the Cretaceous, with a few quite local exceptions.†

* Report of the Geological Survey of North Carol'na, 1875, pp. 150–51.
† Kerr, *op. cit.*, pp. 150–51.

South Carolina.

The Tertiary deposits of this State occupy considerably more than one-half the superficial area, the territory comprised by them having a pretty nearly uniform width of 100–110 miles. The inner boundary line (as indeed is the case for almost the whole Atlantic border) conforms generally with the coast contours, and crosses the State in an almost direct northeast course from about opposite Augusta, in Georgia, via Columbia, to the North Carolina frontier. Throughout its entire extent the formation abuts upon granite or metamorphic rocks, gneisses, schists, and slates, whose exposures mark the first or lowest falls of the descending streams. The line of junction of the rocks of this series, consisting of sands, clays, marlites, and compact siliceous shell conglomerates, or "buhrstones," with those of the Archæan series, is indicated along the entire distance by deposits of sandy strata, which mark the line of distribution of the long-leaved pine (*Pinus palustris*), and support a vegetation essentially distinct from that of the rest of the State.

Eocene.—Mr. Tuomey* recognizes three distinct divisions in this formation, respectively in the order of their position, beginning with the oldest, the Buhrstone, the "Santee beds," and the "Ashley and Cooper beds," the last two principally of a calcareous character, and corresponding to the "Carolina bed" of Ruffin. They form the basement of the so-called "Charleston Basin." The Buhrstone occupies the inner area of the Tertiary formation, extending over a continuous tract between the Savannah River and the Congaree, northwest of a sinuous line connecting Lower (Upper) Three Runs and Vance's Ferry on the Santee and passing on the inside of Allendale, Barnwell and Orangeburg. The thickness of this formation, which at many points along its southern edge and elsewhere can be seen to dip beneath or underlie the Santee beds, has been stated by Tuomey to be upwards of 200 feet, or as much as 400 feet. Its upper member is frequently a layer of greensand, which may be the representative of the similar layer that further to the south, in Alabama and Mississippi, marks the position of the true "Claibornian." However this may be, it is practically certain that the Buhrstone of Tuomey and the greensand together represent a very considerable, if not the greater portion of the deposits which in this State underlie the horizon of the typical "Jacksonian," as the character of the contained organic remains clearly indicates. Their approximate equivalency with the Buhrstone and "Claibornian" may therefore be assumed. Whether the calcareous strata occurring on the Santee below Vance's Ferry, and bordering upon the southern edge of the Buhrstone, be also referable to the "Claibornian" or not, or whether they constitute the correspondent of the "Jacksonian," we have as yet no satisfactory means of determining. It is true that a general similarity exists between their fossil remains and those of the older strata, yet there are a considerable number of forms

* Report of the Geology of South Carolina, 1848.

which are not contained in the older rocks, as *Pecten membranosus*, *P. calvatus*, *P. perplanus*, *Conus gyratus*, several of the Echinodermata, etc., but which, or a number of which, on the contrary, are to be found in the supposed newer strata of the Cooper River, presently to be noticed. Furthermore, if the remains of *Zeuglodon* referred to by Tuomey as having been found in these deposits actually belonged there, and there appears to be no reason for supposing that the observation rests on erroneous data, then we are forced to admit that the beds in question represent a horizon above that of the Claiborne sands on the Alabama River, and more nearly that of the overlying white limestones. The evidence, then, is strong for concluding that the Santee calcareous strata form part of the true Jackson series.* In separating the Ashley and Cooper series from the Santee Mr. Tuomey appears to have been influenced principally by paleontological considerations, rather than by considerations drawn from stratigraphical position, although he alludes to the superposition of the beds in question over those of the Santee.† But if, as is contended,‡ many of the fossils of the Ashley are found on the Cooper, and elsewhere, but as a group they are very distinct from those of every other bed in the State, might it not be assumed, in the absence of facts proving direct stratigraphic continuity, that the two members (the Ashley and the Cooper) of the series indicated are in themselves distinct? But yet they are grouped as one by Tuomey, and not improbably so with reason. And if one, why separate the series from the Santee? We fail to discover from Tuomey's writings that any material difference exists between the faunal facies of this last and the deposits exposed on Cooper River; on the contrary, a very considerable number of the forms are common to both, and among these we have the forms that have already been referred to, *Pecten membranosus*, *P. calvatus*, *P. perplanus*, *Conus gyratus*, etc., besides the Zeuglodon, which ranges through the Santee, Cooper, and Ashley beds. There appears to me to be no good reason for separating the above deposits from each other as indicative of special horizons, although they may occupy different stratigraphical positions in the geological scale, and, therefore, I have retained them as one group, the correspondent of the "Jacksonian."

OLIGOCENE.—What the precise age of the beds on Tinker's Creek and along the Savannah opposite and below Shell Bluff, in Georgia, containing *Ostrea Georgiana*, is—whether upper Eocene ("Shell Bluff" group of Conrad) or Oligocene—still remains to be determined. It appears not unlikely that Hilgard's supposition as to their being of Vicksburg age,§ and their correspondence (as was maintained by Conrad) with the oyster-bed underlying Vicksburg Bluff on the Mississippi River, whose position is between the Jackson and the Vicksburg, is a correct one, although the

* *Ostrea panda*, one of the distinctive Santee fossils, is found abundantly in the basal portion (Jackson) of St. Stephen's Bluff, on the Tombigbee River, Ala.

† *Op. cit.*, p. 162.

‡ *Op. cit.*, p. 163.

§ Am. Journ. Science, new series, vol. xlii, pp. 68–70.

evidence on this point is not yet absolutely confirmatory. Most of the fossils * obtained by Lyell from the face of Shell Bluff are forms that have been identified as exponents of the typical Eocene—"Claibornian" and Buhrstone—but we are not clearly informed what relative position these held to the Georgiana layer, or the layer containing the giant oyster. More direct information on the point in question is given by Ruffin,† who asserts that the oyster-bed, with a development of 4–6 feet, occupies the top marl layer of the bluff overlying what he unhesitatingly calls the "Great Carolinian bed," and which, as we have already seen, is the correspondent in part or in whole of the "Jacksonian." If these observations are to be trusted in their entirety, then there can be but very little room left for speculation on the subject—either the oyster layer forms a part of the Jackson series, or belongs to a deposit of newer age, doubtless the Vicksburg (or Oligocene).

Miocene.—The post-Eocene Tertiary deposits of South Carolina, considered by Tuomey and Holmes to be of Pliocene age, but here referred to the Miocene, occupy, as seen by their outcrops, principally the northeast section of the State, and are most largely developed in Horry, Marion, Darlington, and Sumter districts. As in North Carolina they appear mostly in isolated patches, filling depressions in the underlying Eocene or Cretaceous strata, either along exposed river sections, or on elevated spots that have effectually resisted denudation. South of the Santee River the formation has been traced on the Cooper and some of its tributaries, extending within a few miles of the city of Charleston, and an outlier is noted by Mr. Tuomey as existing on the Edisto below Givham's Ferry. Unfortunately the actual extent of the formation under consideration is not sufficiently well known to permit of its accurate representation on the map, and, therefore, the boundaries there indicated must still be considered in a measure hypothetical. It appears not unlikely that a connecting tract of Miocene exists between the Georgia and South Carolina areas; at any rate, the Edisto deposit above referred to would seem to indicate such connection.

Georgia.

No accurate detail work on the Tertiary geology or paleontology of this State has thus far been attempted; at any rate, no results of such work, if made, have as yet been published. Our knowledge of the subject is still, therefore, mainly of a general or fragmentary character, and not sufficiently precise to permit of its use in either definitely locating the boundaries or defining the approximate extents of the various formations. It is, however, positive that we have here representatives of both Eocene and Miocene, and not unlikely the former is represented in all or nearly all the

* Oliva Alabamensis, Pyrula sp., Turbinella (Voluta) prisca, Melongena alveata, Infundibulum trochiforme, Natica ætites, Crepidula lirata, Dentalium thalloides, Ostrea sellæformis, Nucula magnifica, Cardita rotunda, C. planicosta, Crassatella protexta, Lucina pandata, Cytherea perovata, C. Poulsoni, Lutraria lapidosa. Lyell, Q. J. Geol. Soc., 1, p. 437.

† Rept. Agricult. Surv. of South Carolina, 1843, pp. 22–3 and 34.

various divisions which collectively characterize the formation along the Atlantic and Gulf slopes—*i. e.*, "Eo-Lignitic," "Buhrstone," "Claibornian," and "Jacksonian"—although these divisions have not yet been clearly made out. The Buhrstone appears to occupy the greatest extent; at any rate, whether correctly or incorrectly, it is the formation generally referred to as the typical Georgia Eocene. The Jackson doubtless enters the State along the southern border, although I am not aware that its existence there has been definitely determined through the character of its fossil remains. Mr. Ruffin's determination (?) of the "Great Carolinian Bed" (= Jacksonian) in Shell Bluff, on the Savannah River, has already been referred to in our description of South Carolina, and needs no further comment here Leaving aside the probable existence in the State of the Oligocene formation, as would seem to be indicated by the Georgiana bed, or bed containing the giant *Ostrea Georgiana*, overlying the marl deposits (Ruffin's "Great Carolinian") of Shell Bluff, it is almost positive that the formation in question occupies some little, if not a considerable section of the lower Tertiary area, continuous with the area occupied by the same formation in Florida The later Tertiary deposits occupying the Atlantic border, and having an extent landward of about 60 miles, are probably continuous with, and doubtless of the same age as the later Tertiary deposits of South Carolina, and are accordingly referred to the Miocene.

The Tertiary deposits, which in their entirety occupy considerably more than one-half the area of the State, doubtless rest upon a Cretaceous floor, and abut for the greater part of their extent upon rocks of Archæan age. Their inner boundary corresponds approximately with a moderately sinuous line running from near (a little outside of) Augusta, on the Savannah, by way of Macon, Fort Valley, Montezuma, Americus and Cuthbert, to Fort Gaines, on the Alabama frontier.*

* Since the preparation of the above the writer has received, through the kindness of the author, Dr. Loughridge's notes on the geology of the State (Report on the Cotton Production of the State of Georgia, pp. 14-16; extracted from the Tenth Census Reports, 1884), which, unfortunately, are too brief to add very materially to our knowledge of this division of the geological history. The following section, taken from Mr. Singleton, is given of Shell Bluff, Burke Co.:—

1.	Red loam hill tops,	15–25 feet.
2.	White sandy marl, coarse sand and oysters—*Ostrea Georgiana*,	10 feet.
3.	Coarse drift and shell fragments,	2 feet.
4.	Shell bed—*O. Georgiana*,	13 feet.
5.	White sandy marl,	60 feet.
6.	Indurate marl, with casts of small shells,	2 feet.
7.	White sandy marl,	6 feet.
8.	Indurate marl, with casts of shells and few *Ostrea sellæformis*,	3 feet.
9.	Hard yellowish white marl,	4 feet.
10.	Oyster-bed—*O. sellæformis*,	1 foot.
11.	Hard marl,	5 feet.
12.	Oyster-bed—*O. sellæformis*,	6 inches.
13.	Hard yellowish-white marl,	10 feet.
14.	Fine yellowish sandy marl,	6 feet.
15.	Yellowish-white clay marl,	2 feet.
16.	Indurate marls, with shells,	2 feet.
17.	Whitish-gray clay marl (to water),	15 feet.

The beds containing *Ostrea Georgiana* are referred to the Vicksburg series; No. 5 not improbably represents, either in part or in whole, the "Jacksonian," while the lower portion of the bluff is doubtless largely of the

Florida.

The geological relations of the rocks of this State, as well as the history of their exploration, are clearly set forth in a paper by Prof. Eugene A. Smith, entitled: "On the Geology of Florida," and published in the American Journal of Science, 3d series, vol. 21. It is there conclusively shown that the views entertained by Louis Agassiz and Joseph Le Conte as to the recent and coralline formation of the peninsula are essentially erroneous, and that, as a matter of fact, the greater portion of the peninsula dates back to the Oligocene period, or to the period of the Orbitoitic limestone. Substantial proof of this fact is afforded by the numerous localities where fossils—very largely the genus *Orbitoides* itself, with the species *O. Mantelli*, and others—distinctive of the Orbitoitic formation have been discovered, as in the stretch between Tampa Bay, where they were first identified by Conrad nearly forty years ago, and the Georgia line. Beside the localities where fossils of this class were determined by me to characterize the rock formation, to which reference is made by Dr. Smith, other areas of a like nature have since been discovered, and most notably, perhaps, the territory about Cedar Keys, where, from rock specimens submitted to me by Mr. Joseph Willcox, I was enabled to detect the existence of a true Nummulitic rock, or a rock made up very largely of the united tests of principally one form of Nummulite.* This rock, which is found in the immediate neighborhood of the Cheeshowiska River, in Hernando County, about four miles from the coast, contains in addition to the mass of Nummulites of which it is so largely made up, a sufficient abundance of *Orbitoides*, and also the foraminiferal form which Conrad described as *Cristellaria rotella*, but which I have referred to *Operculina*.† From a locality further to the north, Wacasassa in Levy Co., rock specimens submitted to me were found to contain a number of Echinoids of the genus *Euspatangus*,‡ referable specifically to the forms described by Cotteau from the Oligocene deposits of the island of St. Bartholomew, as *E. Clevei* and *E. Antillarum*.§

From what has preceded, taken in connection with the observations that have been made in western as well as in northern Florida, it may safely be conceded that the underlying rock of the greater portion, if not of nearly the entire State, is of Oligocene age, and therefore no countenance is given to the theory which assumes a recent for-

"Clailornian" age. The Miocene tract, whose rock masses are stated to closely resemble the Grand Gulf sandstone of the Gulf States, is claimed to have a much broader extension than we have above indicated, for if the outcrops observed in Irvin and Dodge Counties really belong to the period in question, which may perhaps still be considered as not yet satisfactorily established, then the inner boundary of the formation will be removed from the coast by about 130 miles. [The Miocene area on the map is according to Loughridge.] The rocks have a slight dip to the southeast, and on the Oconee, where they have been traced for a distance of 60 miles, their development is stated to be 200 feet.

* *Nummulites Willcoxi.* Heilprin, "On the Occurrence of Nummulitic Deposits in Florida, and the Association of Nummulites with a Fresh-water Fauna," Proc. A. N. S., July, 1882.

† The species is not impossibly identical with *O. complanata*.

‡ The generic determination kindly made for me by Prof. Alexander Agassiz.

§ K. Svens. Vet.-Akad. Handl., 1874.

mation. How far south the Orbitoitic limestone extends has not yet been determined, but there appear to be no reasons for assigning it to a limit far removed from the border line of the Everglades. For aught we know to the contrary it may extend quite or nearly to the peninsular extremity.

Barring the post-Pliocene of the coast, the only indication that we as yet have of the existence of any marine formation in the State newer than the Oligocene is the patch of limestone referred to by Dr. Smith *—as occurring at Rock Spring, Orange Co., from which have been obtained specimens identified by me as belonging to the Miocene period—*Pecten Madisonius*, *Venus alveata*, *Cardita granulata*, *Carditamera arata*, and doubtfully, *Mytiloconcha incurva*, *Cardium sublineatum* and *Oliva litterata*. Other Miocene areas will doubtless be discovered, and not impossibly a more or less continuous belt will be found to unite the Rock Spring patch with the Miocene area in Georgia.

Alabama.

The Tertiary formations of Alabama, which occupy a tract in the southern part of the State with a general width varying from about 55 to 90 miles, seemingly exhibit equivalents of all the various subdivisions that have been recognized on either the Atlantic or Gulf borders as intervening between the base of the system and the Vicksburg beds (Oligocene). The Eocene appears here clearly defined in its four divisions, the Eo-Lignitic (Thanetian?), Buhrstone (Londonian?), Claibornian (Parisian, or Calcaire Grossier), and Jacksonian (Bartonian), which follow each other in a general succession (commencing with the lowest) from north to south. Covering the Jacksonian, and occupying a belt immediately to the south of it, are the Vicksburg beds, whose most southern exposure on the Alabama River is at or near Gainestown, some eighty miles north of the Gulf, where the strata pass under the beds that have been designated by Hilgard as the "Grand Gulf Group." Whatever the exact age of the deposits of this group may be, they are the only ones of marine or fluvio-marine origin that indicate along the Gulf border a Tertiary formation of newer date than the Vicksburg: whether they belong to the Miocene period, as has been suggested by Hilgard, or to the Pliocene, can only be ascertained when a more thorough examination of their fossil remains will have been attempted than has heretofore been practicable. For their entire extent the Tertiary deposits abut against those of Cretaceous age, the two having a very nearly equal development, and together occupying about one-half the area of the State. In their eastern half the outcrop or strike of the strata is more nearly due east and west, with a moderate dip to the south, while in the western half the line of outcrop is W. by N.—E. by S., with a dip S. by W. of about 10 feet to the mile.

A convenient starting point in the Tertiary stratigraphy of the State is afforded

* *Loc. cit.*, p. 302.

by the famous bluff exposed on the Alabama River near Claiborne, which has yielded the fossils known to geologists and paleontologists as those characteristic of the "Claiborne Group." Probably the most trustworthy section of this bluff is that given by Tuomey,* as follows:—

		Feet.
g	Red sand, loam, and pebbles.	30
f	Mottled clay.	8
e	Limestone, with grains of greensand.	54
d	Ferruginous sand; numerous fossils.	
c	Whitish limestone.	62
b	Bed of clay 15 feet thick, with seam of limestone on top.	15

NOTE.—Tuomey does not give the thickness of bed "*d*," but it appears from the concurrent statements of different observers to be about 17 feet. The total height of the bluff above the Alabama River would therefore appear to be in the neighborhood of 190 feet.

The measurements and descriptions of Conrad,† Hale,‡ and Lyell,§ do not differ very materially from the data given by Tuomey. The arenaceous bed "*d*," about 80 feet above water-level, has yielded the vast majority of fossils for which the locality is famous, and is that which has been identified as the equivalent of the "Calcaire Grossier" (Upper Eocene of France = Bruxellian of Belgium). Although formerly considered to be near the base of the system, there are now very strong grounds for concluding that these beds are underlaid by older Eocene strata, having a thickness at least 300 feet, and, possibly considerably more. The age of the limestone bed "*e*," although perhaps the character of its contained fossils does not permit of absolute determination, is doubtless at least in part Jacksonian, and will be found to correspond with a portion of the bluff exposed at St. Stephen's on the Tombigbee River, about thirty miles almost due west of Claiborne. At any rate, a portion of the white limestone west of Claiborne has been found to contain several of the characteristic fossils of the Jackson group, and these associated with the remains of *Zeuglodon;* there is, therefore, no doubt as to the age of at least this portion of the white limestone, nor can there be

* First "Biennial Report of the Geology of Alabama," 1850, p. 152.
† "Fossil shells of the Tertiary Formations," 1833, p. 32; Proc. of the Nat. Institute, 1841, p. 174.
‡ "Geology of South Alabama." Am. Jour. of Science, new ser., vi, p. 354.
§ Q. J. Geol. Soc., iv, p. 10, *et. seq.*

any reasonable doubt as to the continuity existing between these deposits, and the similar ones exposed on Claiborne bluff.

Section on Bashia Creek, Clarke Co.—Probably the section representing the oldest Eocene deposits of the State is that exposed on Bashia Creek, detailed by Tuomey in his "First Biennial Report," p. 145 :

1	Hard Limestone.	4 feet.
2	Marl, highly fossiliferous.	25 feet.
3	Blue sand.	Variable.
4	Lignite and clay.	6 feet.
5	Laminated clay, sand, and mud.	Thickness undetermined.
6	Lignite.	do. do.

Note.—Beds 5 and 6 do not properly belong to the section, but "represent beds seen on another part of the stream below the preceding" (Tuomey, *loc. cit.*, p. 146).

Beds corresponding to No. "2" of the above section are likewise exposed on Cave and Knight's branches, tributaries of Bashia Creek, and have been shown by Dr. Eugene A. Smith to underlie the *base* of the "Buhrstone" proper by nearly (if not more than) 200 feet.* The relations of these various beds will be best understood by a reference to the sections exposed on the Tombigbee River.

Sections on the Tombigbee River.—At Wood's Bluff, near the mouth of Bashia Creek, we have the following exposure:—

No.		Feet.
7	Orange sand, or stratified drift.	10–20
6	Grayish or greenish laminated clays, colored brown by iron.	10
5	Ledge of bluish or greenish sand, fossiliferous—capped by a ledge of hard nodules.	2
4	Bluish laminated clay, with few fossils.	5
3	Indurated greenish sand, full of the same shells as marl bed No. 2.	3
2	Greensand marl, quite soft, and full of shells.	3
1	Indurated greensand with shells, and a stratum of oyster-shells at water's edge—said to extend 10 feet further down.	10–15

Bed No. 4 is considered by Dr. Smith to be most closely related in the character of its fossil remains to the fossiliferous strata exposed on Cave and Knight's branches, and it is therefore not unlikely that the series 1–5 correspond in the main with No. 2

* Heilprin, Proc. Acad. Nat. Sciences, 1881, p. 369.

of Tuomey's Bashia section.* The basal lignite would then probably be found to underlie the lowest stratum exhibited at the Bluff. Bed No. 6 (Wood's Bluff section) can be traced down the river for a distance of two or three miles, when it dips beneath the water's level. Somewhat below this point, and beyond the mouth of Witch Creek, the stratigraphical relation of the different beds is beautifully exhibited in a prominent cliff ("White Bluff"), rising from 250 to 275 feet above the river. The upper portion of this bluff is constituted by the characteristic siliceous clay-stones and silicified shell deposits of the southern "Buhrstone" formation, which make up fully 100 feet of the vertical height. Laminated lignitic clays (bearing numerous leaf impressions), with occasional intercalated beds of pure lignite, enter mainly into the composition of the intermediate portion, *i. e.*, from the water's level to the base of the buhrstone above mentioned. Allowing a uniform southerly dip of 10 feet to the mile, which appears to be consistent with obtained data, it is manifest that at this point the lowest fossiliferous strata exposed at Wood's Bluff (and consequently the equivalent deposits on Bashia Creek and its tributaries, Cave and Knight's branches) must lie from 175 to 200 feet below the base of the siliceous mass constituting the true buhrstone; or in other words, we have here a series of deposits aggregating about 300 feet in thickness, which can be shown to be of an age anterior to the deposition of the Claiborne fossiliferous sands. At Baker's Bluff, a few miles above St. Stephen's (which is situated some twenty-eight miles south of Wood's Bluff), the buhrstone, according to Tuomey, appears in a vertical escarpment rising only 50 feet above the water, a low height perfectly in accordance with the loss occasioned by the general dip extending over nearly twenty miles. At this point, moreover, occupying a position above the buhrstone, Tuomey (*op. cit.*, p. 148) identifies a bed of greensand, 8 feet in thickness, as the equivalent of the Claiborne fossiliferous sands ("*d*" of his section), and containing numerous fossils identical with those found at Claiborne. Still further south, and occupying a considerably lower level, the same bed is described as having a development of 12 feet, and immediately above St Stephen's was seen to dip beneath the water's edge. At this last locality we have a beautiful exhibit of what has generally been designated by the name of "White Limestone."†

There can be not the least doubt, however, that this "White Limestone," which has most frequently been taken to represent bodily the Vicksburg (Oligocene or "Orbitoitic"), is in reality, as has been long ago insisted upon by Winchell,‡ a combination of strata belonging to two distinct groups of deposits. The lower moiety, dipping into the river, and resting upon the subjacent Claiborne sand (Tuomey, *op cit.*, p. 157; Lyell, Q. Journ. Geol. Soc. Lond., iv, p. 15; Hale, A. J. Science, new ser., vi, p. 359),

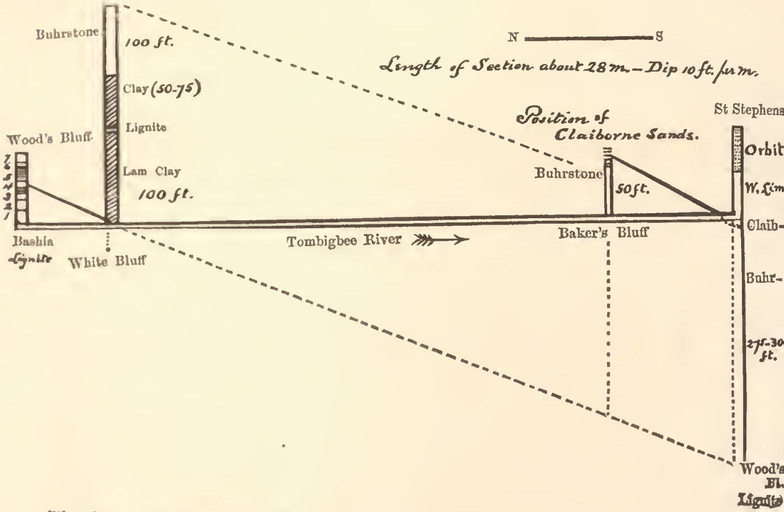
* The relations of the Bashia and Wood's Bluff sections, as well as those of Cave and Knight's branches, are fully set forth in my paper above referred to, Proc. A. N. S., 1880, pp. 364–70.

† I have been unable to discover the exact height of this bluff. Neither Lyell nor Tuomey mentions it; Conrad, in the appendix to Morton's "Synopsis" (p. 23), states it is about 100 feet.

‡ Proc. Amer. Assoc., 1856, part ii, p. 85.

is the true "White Limestone," an exponent of the Jacksonian group of deposits, as is clearly indicated by the character of its contained fossils.* Were it otherwise the case, it would be very difficult to explain the total disappearance over a distance of only thirty miles (and with but exceedingly moderate dip) of the equivalent beds exposed on the Alabama River at Claiborne. The upper moiety, on the other hand, is a portion of the well-known Orbitoide (Vicksburg or Oligocene) rock, and is that which alone contains specimens of *Orbitoides Mantelli* (Winchell, *loc. cit.*, p. 85).

From the data here presented, a section of the Tertiary strata traced along the Tombigbee River from Wood's Bluff to St. Stephen's, may, with considerable approach to truth, be constructed as follows:—



The foregoing section shows almost conclusively that the Eocene deposits of Alabama have a thickness of very nearly 400 feet; and, indeed, Dr. Smith, State Geologist, informs me that there are good grounds for supposing that Tertiary beds occur along the northern outcrop, whose position would be still 150–180 feet below the Wood's Bluff marl bed. It will further be seen that the "Claibornian" (or Claiborne proper, as characterized by the fossiliferous greensands) holds a position decidedly near the top of the series, a position almost precisely similar to that occupied by the "Calcaire Grossier" (Parisian) of France, more properly Upper than Middle Eocene,

* *Spondylus dumosus* and *Ostrea panda*, originally described as characteristic fossils of the newer Cretaceous (upper Eocene) of the southern United States, have been found abundantly near the base of the bluff.

which last it has very generally been considered. What relation beds "*b*" and "*c*" of the Claiborne Bluff hold to the sub-Claibornian ("Buhrstone" in part) deposits of the Tombigbee River has not yet been absolutely determined; but there can be no legitimate doubt that they represent, in a modified form, the upper moiety of those deposits. Although the marked difference in the lithological character of the strata of the two localities as compared with each other (and, indeed, it must be confessed, this is much greater than could have been reasonably inferred from the general constancy of the deposits in this region) would seem to militate against such a view, there is, nevertheless, sufficient evidence, both stratigraphical and paleontological, to support this conclusion. In the first place, by determining the position of the buhrstone rock near St. Stephen's as immediately underlying the highly fossiliferous greensand layer, Tuomey has proved that the two series of deposits (the "Buhrstone" on the Tombigbee, and bed "*c*" on the Alabama) hold relatively the same position to the true Claibornian, lying immediately below it. In the second place, the argillaceous strata at the base of Claiborne Bluff (bed "4" of Hale's series) have been identified by Hale, both on lithological and paleontological evidence (A. J. Science, new ser., vi, p. 356), as occurring at Coffeeville Landing on the Tombigbee River, about fourteen miles north of St. Stephen's, what might very readily have been expected from an inspection of the general lay of the different formations.* No data are given relative to the position of the "Buhrstone" at this last locality, but hypothetically considered (as deduced from its position at White Bluff, and its general dip), its summit must still occupy a position fully 100 feet above the level of the river; and this thickness (100 feet) coincides very closely with the thickness (80–90 feet) of the deposits below the true Claibornian (bed "*d*") as exposed in the bluff on the Alabama River. And finally, that at least a very considerable portion of the inferior beds at this last-named locality represent strata of a different lithological character in other portions of the State—and consequently, that they are local deposits—is proved by the concurrent statements of Hale (*loc. cit.*, p. 356) and Winchell (*loc. cit.*, p. 86), both of whom assert that the calcareous deposit below the arenaceous bed (not the "White Limestone") is not known to occur at any other locality.

From the data here presented, it will be seen that the Alabama Eocene formation comprises:

4. "White Limestone" (Jacksonian), best exhibited at Claiborne (upper portion of bluff) and St. Stephen's (lower moiety of bluff), not very abundant in fossils—*Pecten membranosus*, *P. Poulsoni*, *Ostrea panda*, *Spondylus dumosus*, "*Scutella*" *Lyelli*, etc.—50—? feet.

* A line uniting Claiborne and Coffeeville Landing would run almost precisely parallel with the line marking the junction of the Cretaceous and Tertiary deposits lying hence due north. The contour lines traced by Tuomey would indicate a *true* dip west of the southerly line, and that this is actually the case is proved by the difference (80–90 feet) between the actual heights at which the equivalent beds at St. Stephen's and Claiborne are placed. This also agrees with Hilgard's observations in Mississippi, where the dip of the Jackson and Vicksburg strata was found to be about 10 to 12 feet per mile S. by W. (A. J. Science, new ser., xliii, p. 36).

3. The fossiliferous arenaceous deposit (Claibornian), best shown at Claiborne—subaqueous at St. Stephen's—very rich in fossils, and of the age of the "Calcaire Grossier" of France.—17 feet.

2. "Buhrstone" (Siliceous Claiborne of Hilgard), comprising siliceous clay-stones (buhr-stone proper) densely charged with fossils or their impressions, laminated clays, sands and calcareous deposits—beds "*b*" and "*c*" of the Claiborne section, the cliff at White Bluff, and the so-called "Chalk Hills" of the southern part of the State. At Claiborne the representative beds consist of aluminous and calcareous deposits, poor in fossils, but containing occasional layers of *Ostrea sellæformis.*—About 250 feet?

1. The Wood's Bluff and Bashia (with Cave and Knight's Branches) deposits (Eo-lignitic), consisting of alternating dark clays, greenish and buff sands, and numerous seams of lignite, partly very rich in fossils, and as far as is yet *positively* known, the oldest Tertiary deposits of the State.—50—? feet.*

The exact development of the Vicksburg (Oligocene) and Grand Gulf (Miocene?) deposits, has not yet been determined.

It appears very probable, from the investigations of Prof. L. C. Johnson, that the limits of the Tertiary formation extend considerably farther to the north than have generally been represented on the maps, the northward extension at Allenton being ten miles, six at Camden, and seventeen at Butler Springs †

Mississippi.

The Mississippi Tertiary formations, which cover by far the greater portion of the State, exhibit essentially three different facies: variously colored lignitiferous clays and sands—black, brown, blue, green, yellow, gray, and impure white; siliceous sandstones and claystones containing marine fossils; and limestones and calcareous marls, also with marine fossils. Lignitic clays occur intercalated throughout almost the entire series of deposits, and conversely, small estuarine deposits of marine shells occasionally appear in the true lignitic strata.‡ All the subdivisions recognized in Alabama are also to be met with here, and as in that State, they follow each other in regular succession from north to south. The dip appears to be nearly conformable to that of the subjacent and eastwardly located Cretaceous deposits, being westward—about 4–5 feet per mile—in the northern part of the State, and southward—10–12 (average) feet per mile S. by W.—in the southern part.§

* The "Buff Sands" of Winchell (*loc. cit.*, p. 89) probably falls into this group, but its exact position, or its correspondent, does not appear to be as yet definitely determined. It is seen to underlie the "Buhrstone," and is considered by Winchell to represent the absolute base of the Tertiary system of the State. At Black's Bluff, Wilcox Co., it is stated to repose directly on the subjacent Cretaceous limestone, but in a foot-note (p. 90), we are informed that, according to Tuomey, the characteristic fossil of this limestone, an *Ostrea*, is probably Tertiary.

† *Science*, vol. ii, p. 777 (Dec., 1883); iii, p. 32 (Jan., 1884).

‡ Hilgard, "Agriculture and Geology of Mississippi," p. 107, 1860.

§ Hilgard, Am. J. of Science, new ser., xliii, p. 36, 1867.

The following generalized section, slightly emended from Hilgard, is given upon the data furnished by that authority; the approximate thicknesses may be taken as *minima*, being often greatly exceeded.

1. Grand Gulf Group, or southern Lignite (Miocene ?)—variously colored sandstones, with small lignite beds, tree-palms, exogenous trees, *Arundinaceæ.*—150 feet.

2. Vicksburg beds (Oligocene—"Orbitoitic").

   a. Crystalline limestones and blue marls, with *Ostrea Vicksburgensis*, *O. gigantea*, *Pecten Poulsoni*, *Cardium diversum*, *Arca Mississippiensis*, *Navicula Mississippiensis*, *N. lima*, *Crassatella Mississippiensis*, *Panopea oblongata*, *Fulgoraria Mississippiensis*, *Cypræa lintea*, *Dentalium Mississippiensis*, *Madrepora Mississippiensis*, *Orbitoides Mantelli.*—80 feet.

   b. Ferruginous rock of Red Bluff ("Red Bluff Group" of Hilgard, typically exposed in the bluffs of Chickasawhay River, near Red Bluff Station, Wayne Co.—the correspondent of the "Shell Bluff Group" of Conrad ?), with *Plagiostoma* (*Spondylus*) *dumosa*, *Cardita planicosta*, *C. rotunda*, *Rostellaria velata*, *Fulgoraria Mississippiensis*, *Mitra Mississippiensis*, *Cassidaria lintea*, *Conus sauridens*, *Busycon spiniger*, *Natica Vicksburgensis*, *Trochita trochiformis*, *Dentalium thalloides*, *Osteodes*, *Madrepora*, *Flabellum Wailesii.*—12 feet.

   c. Lignitic clay and lignite, as shown at the base of Vicksburg bluff.—20 feet.

3. Jackson beds ("Jacksonian"= Bartonian). White (often indurate) and blue marls, underlaid by lignitic clay and lignite, with *Zeuglodon macrospondylus*, *Cardita planicosta*, *Cardium Nicolleti*, *Leda multilineata*, *Corbula bicarinata*, *Rostellaria velata*, *Gastridium vetustum*, *Morio Petersoni*, *Voluta dumosa*, *Mitra Millingtoni*, *M. dumosa*, *Conus tortilis*, *Cypræa fenestralis*, *Trochita alta*, *Umbrella planulata*, *Flabellum Wailesii*, *Osteodes irroratus.*—80 feet.

4. Calcareous Claiborne ("Claibornian"—age of the "Calcaire Grossier").—White (sometimes indurate) and blue marls, with the well-known Claiborne fossils. —? feet.

5. Siliceous Claiborne ("Buhrstone"—Suessonian in part).—Sandstones and claystones with Claiborne fossils.—? feet.

6. Lignitic or Northern Lignite ("Eo-Lignitic")—Basal lignites, with interstratified clays and sands, containing marine fossils, and (Tippah) plant remains—*Quercus*, *Carya*, *Populus*, *Morus ?*, *Ficus*, *Laurus*, *Persea*, *Cornus*, *Olea*, *Rhamnus*, *Terminalia*, *Magnolia*, *Dryandroides ?*, *Rhus.*—425—? feet.

Considerable uncertainty still exists relative to the age and position of the deposits constituting the Northern Lignite. Their local variability, uniformly moderate dip (or even horizontality), and dearth of fossil (animal) remains, combined with the circumstance that at only a few localities is a superposition of strata distinctly observable, render a positive determination difficult, if not impossible. That the region of the "Flatwoods" bordering the Cretaceous formation on the west, and extending to the northern boundary of the State, is of the same age as the formation occurring in Lauderdale and Neshoba Counties, which can be distinctly traced beneath the Siliceous Claiborne or "Buhrstone," there can be but little or no doubt, and, therefore, as far as the age of this section is concerned, nothing further need be said. But whether all the lignitic territory lying north of the marine Tertiary boundary, and occupying nearly the whole northern half of the State, belongs to the same geological period (Eo-Lignitic), as Hilgard appears disposed to believe,* may well be considered doubtful. On the contrary, it appears far more reasonable to suppose, seeing the position occupied by the outlier of the Siliceous Claiborne in Carroll, Holmes, Attala and Choctaw Counties (Shongalo, Valden, etc.), that the lignitiferous deposits, or at least a portion of them, of these counties, as well as of Yazoo, Madison and Leake, and possibly also of Yallabusha, belong to a much newer period, not improbably the Jacksonian. Hilgard clearly affirms that the marine outlier here referred to is as well *over* as *underlaid* by lignito-gypseous strata;† again in a boring made in the Jackson penitentiary well, and penetrating, as stated, to a depth of 470 feet, what would appear to be a continuation of the Shongalo (Siliceous Claiborne) deposits was struck at 450 feet, or 418 feet below the strata recognized to be of Jackson age. Granting the correct determination of the Shongalo deposit, it is evident that the 418 feet of lignitic clays passed through before the 20 foot shell-bed was reached, and regarding which "there can be little doubt that it, also, is of the Claiborne age," must represent something much newer than the basal lignites, and not improbably, as has already been suggested, the Jacksonian (at least in principal part).‡ Such a reference would be much more nearly in accord with the disposition of the Jackson beds in the adjoining State of Louisiana, where, according to Hopkins, the strata are also very largely lignitic, and where they occupy the greater part of the area included between the "Vicksburg" line and the Arkansas boundary.§ They doubtless extend for a considerable distance into Arkansas, largely entering into the formation of the Mississippi

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* "Agriculture and Geology of Mississippi," p. 109; Am. J. of Science, new ser., vol. xliii, p. 35.

† *Op. cit.*, pp. 122–3.

‡ Hilgard is not very explicit in his reference to the Shongalo deposit. While considering it an exponent of the Siliceous Claiborne in his geological reports of the State, in a later article, "On the Tertiary Formations of Mississippi and Alabama" (Am. J. of Science, xliii), the deposit in question is referred to the Lower Lignite on p. 34, and, again, on the following page we have mention of "the marine outlier of the Claiborne age, in Carroll and Attala."

§ Second Annual Report of the Geological Survey of Louisiana, p. 8, 1870.

embayment, and meet their continuation on the other side of the river in the State of Mississippi.

Siliceous and Calcareous Claiborne.—There can be no question that the deposits we have recognized in Alabama and elsewhere as the "Buhrstone" and the "Claibornian" have their exact counterparts in Mississippi, and that these correspond in a general way with what Hilgard has designated the "Siliceous Claiborne" and the "Calcareous Claiborne" respectively. The former extends in a belt, some twenty miles wide, westward from the Alabama line nearly half across the State, reappearing as outliers in Carroll and Attala counties in the deposits of (near) Valden and Shongalo, to which reference has already been made in the discussion of the Northern Lignite. Among its commoner fossils are *Cardita planicosta*, *C. rotunda*, *Cardium Nicolleti*, *Ostrea divaricata*, *Pecten Lyelli*, and *Voluta petrosa*. From the locality of Enterprise, on the Chickasawhay River, Clarke County, situated on the line of contact of the "Siliceous" and "Calcareous Claibornes," as indicated by Hilgard, Mr. Conrad in 1865 described the following species of mollusca, claimed to be all new, "and distinct from those of any other locality from which fossils have been sent to the Academy;"* *Ostrea falciformis*, *Eburneopecten scintillatus*, *Arcoperna filosa*, *Nucula spheniopsis*, *Leda linifera*, *Axinæa* (*Pectunculus*) *inequistria*, *A. duplistria*, *Gouldia pygmæa*, *Crassatella producta*, *Protocardia lima*, *Cyclas curta*, *Sphærella bulla*, *Alveinus minuta*, *Cytherea securiformis*, *C. annexa*, *Tellina eburneopsis*, *T. albaria*, *Tellinella linifera*, *Corbula filosa*, *Doliopsis quinquecosta*, *Turritella perdita*, and *Mesalia? arenicola*.†

The true "Claibornian," consisting of blue marl and white marlstone, is but very feebly developed in the State, occupying a narrow strip, some thirty to forty miles in length, mainly in Clarke County, wedged in between the Buhrstone and Jackson. The fossils, in distinction to those of the corresponding Alabama deposit, are very imperfectly preserved, and in most cases specifically unrecognizable. The leading forms are: *Ostrea sellæformis*, *O. divaricata*, *Pecten Lyelli*, *Corbula gibbosa*, (*C. onisus*, Conr.; *C. rugosa*, Lam.) and *Voluta petrosa*.

Jackson and Vicksburg.—The deposits of the Jackson and Vicksburg (Oligocene) periods occupy parallel bands passing across the State, disappearing in the west under the Mississippi alluvium. The most distinctive fossil of the former is the *Zeuglodon*, and of the latter *Orbitoides*, represented by two (*O. Mantelli*, *O. nupera*), or more species. Although by several observers, including Conrad, the fossils here indicated have been at various times referred to as occurring together in the same deposit, there can be but little question, as has been insisted upon by Hilgard, that

* Am. Journ. of Conchology, i, pp. 137–41.

† Most of these are doubtless distinct, but it would be difficult, if not impossible, to distinguish between *Ostrea falciformis* and *O. divaricata*, *Nucula sphæniopsis* and *N. ovula*, and *Cytherea annexa* and *C. perovata*, common Claiborne fossils.

either such reference has been based upon error, or that the interassociation, where it actually exists, dates to a period subsequent to that of the original deposition of the strata. At any rate, the painstaking investigations of the geologist last mentioned, have failed to reveal a single instance where an "Orbitoid has been found associated with either the Zeuglodon, or any of the characteristic fossils of the Jackson group."* From the neighborhood of Jackson, on the Pearl River, Conrad, in 1855, described the series of fossils which led him to institute a distinct division of the Eocene under the name of the "Jackson," and which he correctly located between the Claiborne and Vicksburg beds. Of the forty species described from this locality † thirty-four were considered to be peculiar, and only five—*Rostellaria velata*, *R. staminea*, *Scalaria nassula*, *Pseudoliva vetusta*, and *Endopachys expansum*—common to the Claiborne series. None of the Vicksburg fossils were considered to be represented. From the nature of his collection, which was a selected one, Conrad was led to infer that a far greater dissimilarity existed between the Jackson and Claiborne series on the one side, and the Jackson and Vicksburg on the other, than the actual facts warranted. In addition to the Claiborne fossils already mentioned as occurring in the Jackson beds, Prof. W. D. Moore ‡ mentions *Cardita planicosta* and *Cardita rotunda*; and as common to the Vicksburg series *Cardita rotunda*, *Navicula* (*Arca*) *lima*, *Cytherea sobrina*, *C. imitabilis*, *Mactra funerata*, *Psammobia lintea*, *Turbinella Wilsoni*, *Cypræa lintea*, *C. sphæroides*, *Natica Vicksburgensis*, and *Dentalium Mississippiense*. §

That a much closer connection exists between the deposits of the Jackson and Vicksburg series than was supposed by Conrad is proved by the character of the fossils occurring at or near Red Bluff Station, on the Chickasawhay River, in deposits lying intermediate between the Jackson and the typical Vicksburg, and considered by Hilgard to represent a subordinate group (Red Bluff Group) of the Vicksburg series. Of twenty specifically identified forms, ‖ Prof. Moore enumerates ¶ four,—*Cardita planicosta*, *Clavelithes humerosus?*, *Rostellaria velata* and *Flabellum Wailesii*—as being common to the Jackson beds, and twelve to the Vicksburg—*Cardita rotunda*, *Cardium diversum*, *Fulgoraria Mississippiensis*, *Turbinella protracta*, *T. perexilis*, *Buccinum Mississippiensis*, *Cassidaria lintea*, *Mitra Mississippiensis*, *Busycon spiniger*, *Conus sauridens?*, *Natica sigaretina* and *N. Vicksburgensis*.

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* A. J. Science, new ser,, xliii, p. 30.

† Proc. A. N. S., 1855, pp. 257–63; figures in Wailes' "Agriculture and Geology of Mississippi," 1854.

‡ In Hilgard's Agriculture and Geology of Mississippi, 1860, p. 132.

§ The author has not had the opportunity of verifying these determinations, and many others referred to by the various State Geologists. While accepting many of them, he feels inclined to express doubt in the case of others, seeing what difficulty attaches to correct identification from scanty materials, especially in the case of forms very imperfectly described and figured.

‖ *Cardita planicosta*, *C. rotunda*, *Pecten nuperus*, *Cardium diversum*, *Rostellaria velata*, *Fulgoraria Mississippiensis*, *Clavelithes humerosus*, *Turbinella protracta*, *T. perexilis*, *Busycon spiniger*, *Buccinum Mississippiense*, *Cassidaria lintea*, *Mitra Missisippiensis*, *Conus sauridens?*, *Cypræa sphæroides*, *Natica Vicksburgensis*, *N. sigaretina*, *Trochita trochiformis*, *Dentalium thalloides?* and *Flabellum Wailesii?*

¶ *Loc. cit.*, p. 136.

The following section of the bluff at Vicksburg, on the Mississippi, whence Conrad obtained the fossils characteristic of the Vicksburg group, described in the Proceedings of the Academy of Natural Sciences of Philadelphia, for October, 1847 (and Journal of the same institution, vol. i), is given by Hilgard:

g. Calcareous silt with snails—Bluff formation.—10–20 feet.

f. Bluish and yellowish hardpan, often pebbles—Orange sand.—5–20 feet.

e. Alternating strata, 1 to 6 feet thick, of limestone and marl, containing the *Vicksburg fossils*, and some bands of non-effervescent gray sand and clay.—60–65 feet.

d. Black lignitic clay and gray sand, with *Ostrea gigantea*, *Corbula alta*, *Natica Mississippiensis*, *Cytherea sobrina*, *Madrepora Mississippiensis*.—5 feet.

c. Gray or black lignitic clays or sands, with iron pyrites; exuding salts and sulphuretted hydrogen.—25 feet.

b. Solid, lustrous lignite, with whitish cleavage planes.—3 feet.

a. White limestone of the Jackson group?—3 feet.

The white limestone *a* of the above section, which "is visible only at extraordinary low stages of water," appears to be of Jacksonian age, although conclusive paleontological evidence on this point is still wanting. Stratum *d*, containing *Ostrea gigantea* (=*O. Georgiana*), is that which has been identified by Conrad as corresponding to the Georgiana bed of Shell Bluff, on the Savannah River ("Shell Bluff Group"),* and which is erroneously stated to underlie the Jackson beds. The fossils associated with the large oyster in the Vicksburg Georgiana bed—*Corbula alta*, *Meretrix sobrina*, *Natica Mississippiensis*, *Natica Vicksburgensis*, *Fulgur nodulatum*, *Madrepora*, etc., show affinities alike with both the Jackson and Vicksburg faunas, and in this respect, as well as in stratigraphical position, would seem to point to a deposit, as has been urged by Hilgard, the correspondent of the "Red Bluff" series (as restricted to the Red Bluff group) on the Chickasawhay. At both localities the position is immediately below the Orbitoides rock, but at Red Bluff Station, the large oyster is wanting.

The relations of the Jackson and Vicksburg series of deposits to the geological scale have been discussed in the introductory portion of this paper.

Grand Gulf Group (Miocene?).—The newest Tertiary formations of Mississippi are constituted by the deposits of the "Grand Gulf Group" of Hilgard, which immediately succeed the Vicksburg beds to the south, and constitute the highest ridges in the southern portion of the State. "At their lines of contact, the Vicksburg

* A. J. Science, new ser., xli, p. 96.

and Grand Gulf rocks consist almost throughout of lignito-gypseous laminated clays, passing upwards into more sandy materials; they are not sensibly unconformable in place; but while the Vicksburg rocks show at all long exposures a distinct southward dip of some three to five degrees, the position of the Grand Gulf strata can rarely be shown to be otherwise than nearly or quite horizontal on the average; although in many cases faults or subsidences have caused them to dip, sometimes quite steeply, in almost any direction." *

Towards the sea-coast, the lithological transition into the post-Pliocene is about equally well marked as the transition into the older deposits in the north. The most remarkable circumstance connected with the Grand Gulf deposits is the almost total absence of zoogene fossils, whether land, marine or fresh-water. Up to 1881 it appears that only one solitary fragment of such fossil, determined to belong to a turtle, had been discovered;† and even the plant remains are in most cases unrecognizable, although the general regularity of the strata, as well as their lithological character, would seem to indicate that they were laid down under most stable conditions, or such as would be most conducive toward animal or plant preservation. Whether the temporary seclusion or cutting off of the Gulf from the Atlantic, as has been premised by Hilgard, was a, or the primary cause in bringing about this anomalous condition, still remains to be proved, and it further remains to be proved that any such seclusion actually took place.

Louisiana.

The general features of the Tertiary formations of this State are very much like those of Mississippi, and call for no special consideration. Only three divisions of the series, the Jackson, Vicksburg, and Grand Gulf, are officially recognized, ‡ but it is not improbable that the Claiborne enters the northwest corner.

The exposures of the Vicksburg beds occupy a belt 10–15 miles or more § in width extending in a west–southwest direction from the Washita to the Sabine River. The distinctive fossils of the group are sufficiently abundant, and we find, as in Mississippi, a frequent association of *Orbitoides Mantelli*, *Ostrea Vickburgensis*, and *Pecten Poulsoni*. North of the Vicksburg line to the Arkansas boundary the strata are largely of a lignitic character, and indicate distinct alternations of marine and brackish-water conditions. They are collectively grouped under the Jackson period ("Mansfield Group," in part, of Hilgard), a position seemingly indicated by the character of the fossil remains. The remains of *Zeuglodon* have been found at Montgomery, in Grant parish, and at Grandview, on the Washita, a few miles below Columbia. Of about 150 species of invertebrate fossils collected from these deposits, it is claimed that at least nine

* Hilgard, A. J. Science, new ser., vol. xxii, p. 58.
† Hilgard, A. J. Science, new ser., vol. xxii, p. 59.
‡ Hopkins, "Second Annual Report of the Geological Survey of Louisiana," 1871.
§ Stated to be 30 miles by Hilgard, A. J. Science, new. ser., vol. xlviii, p. 339, 1869.

occur, that in Mississippi are found in the Vicksburg beds alone, viz.: *Madrepora Mississippiensis*, *Orbitoides Mantelli*, *Avicula argentea*, *Terebra tantula*, *T. divisura*, *Pleurotoma porcellana*, *Pyrula* (2 species, undetermined), *Phorus humilis*, and *Ringicula Mississippiensis*. To this is also added *Ostrea Georgiana*. The occurrence here claimed, of *Orbitoides Mantelli* and *Ostrea Georgiana*, two forms whose horizons in Mississippi appear to be so trenchantly severed from the Jackson, would seem to throw some doubt upon the accuracy of the boundaries of the various formations as laid down.

South of the Vicksburg line the deposits of the Grand Gulf group, destitute of fossil remains just as in Mississippi, extend across the State; they are succeeded to the south by the deposits of what Hilgard has termed the "Port Hudson Group" (Post-Pliocene; "Coast Pliocene" of Mississippi).

Arkansas.

About one-half of this State is occupied by the Tertiary formation, concerning whose development we are unfortunately provided with but very few reliable data. The various divisions have not yet been paleontologically defined, but probably the series includes the pre-Clairbornian, the Claiborne, and the Jackson. The presence of the last is inferred from its position in the State of Louisiana, where, as it has been seen, it extends to the Arkansas boundary. Lignitic deposits occur largely throughout the Tertiary area, and while some of these doubtless represent the basal beds of the Eocene, as has been premised by Owen,*, others (of the S. E. section of the State) not improbably form the continuation of the Jackson lignites of Louisiana. Claiborne fossils—*Cardita planicosta*, *Cytherea* (probably *C. Nuttalli*), *Corbula oniscus*, *Pseudoliva vetusta*, *Turritella* (probably *T. carinata*), and *Voluta* (*V. Sayana?*)—have been obtained, among other localities, at "White Bluffs" on the Arkansas River (about latitude 34° 27′), and much the same assortment from the neighborhood of Madison, St. Francis Co., on Crow creek.†

Texas.

The Tertiary formations of this State are as yet too imperfectly known to admit either of an absolute localization of the various boundary lines, or of an accurate subdivision into the minor geological groups. It may be safely assumed, however, from the geological conformation of the neighboring States, that all, or nearly all of the divisions ranging from the Eo-Lignitic to the Grand Gulf inclusive, are represented, and that the position occupied by these follow each other in regular succession, beginning with the oldest, from the interior coastward, with a general dip to the southeast or east. The geological notes on this region by Schott, Hall, and Conrad,‡ and of Shumard § and Buckley ‖ are exceedingly meagre and unsatisfactory, and give us barely more than a general idea as to where the Tertiary formation exists.

* "Second Rept. Geol. Recon. of the Middle and Southern Counties of Arkansas," 1860.
† Owen, *op. cit.*, pp. 35, 152, and 417; Plate IX.
‡ Emory's Report, Mexican Boundary Survey, i, 1857.
§ First Report of Progress, Geol. and Agr. Survey of Texas, 1859.
‖ First Annual Report, 1874; Second Annual Report, 1876.

According to Dr. Loughridge, who, more than any other geologist, has closely investigated the outcrops of the different formations occurring throughout the State, the Cretaceo-Tertiary boundary line starts on the northeast from the Red River, at a point a few miles above Texarkana, on the Arkansas frontier, and taking a generally southwestern direction—passing at or near Clarksville (Red River Co.), Corsicana (Navarro Co.), Marlin (Falls Co.), Cameron (Milam Co.), Elgin (Bastrop Co.), Seguin (Guadeloupe Co.), and the northwest corner of Atascosa—crosses the Rio Grande at about the mouth of Las Moras Creek, a little south of the Pecos River, and to the north of Eagle Pass.*

The westerly deflection indicated as beginning a few miles south of San Antonio, and extending to the Rio Grande, can scarcely be said to be definitely proved as yet, although Loughridge affirms† that "the glauconitic sandstones, mentioned by Mr. Schott as occurring along the river [Rio Grande] from the Cretaceous rocks at the mouth of Las Moras Creek, north of Eagle Pass, southward to Roma, near Rio Grande City, are doubtless of Tertiary age." Further evidence is needed on this point, however, although some confirmation of the supposition is lent by the discovery of Tertiary fossils (*Cardita planicosta*, among others), in a locality, Arroya las Minas, situated between El Paso and Leon (where?)‡

Among the common Tertiary fossils occurring in Texas Buckley identifies§ *Ostrea selliformis*, *Pecten Lyelli*, *Astarte Conradi* (= young of *Crassatella alta*), *Cardita planicosta*, and *Turritella carinata*; and there can be but little doubt, as claimed by Buckley, that the Eocene of Bastrop, Robertson, and Leon counties, and thence along the eastern border of the Cretaceous, northward to Red River County, belongs, if not mostly, at least in considerable part "to the lower Eocene, as seen at Claiborne, Alabama, and in Clark County, west of Claiborne." How much of it belongs to the true "Claibornian," still remains to be determined. Loughridge states that "the Claiborne group of white limestones and fossils has not been recognized in Texas;" the word "Claiborne" probably here stands for either "Jackson" or "Vicksburg," although there can be little, if any, question as to the existence of both of these formations, if nowhere else, at any rate along the Louisiana boundary.‖

* Cotton Production Report, pp. 18, 21, 1882, forming part of vol. v of the Tenth Census Reports.

† *Op. cit.*, p. 21.

‡ Conrad, in Emory's Report.

§ First Annual Report. p. 64.

‖ The series of fossils described by Gabb in the Journal of the Academy of Natural Sciences (new ser., vol. iv), from Wheelock, Robertson County, and from Caldwell County, although comprising many forms quite distinct from any hitherto found in the "Claibornian" of either Mississippi or Alabama, appear by the general facies to belong more nearly to that group than to any other; yet among the number occur a few forms recalling a newer horizon. The author has been able to identify fragments obtained from an artesian well-boring in Palestine, Anderson County, about 50 miles southeast of the western outcrop of the Eocene, and from a depth beneath the surface of 540–610 feet (or 50–120 feet below the level of the Gulf), as belonging to *Cardita planicosta*, *Voluta Sayana*, and *Turritella carinata*. *Cardita planicosta*, or perhaps rather the form known as *C. densata*, associated with *Turritella carinata* and other Claiborne fossils, have also been detected by the author in limestone blocks from Laredo, on the Rio Grande, and he has described, as new forms, *Pleurotoma platysoma*, *Fusus* (*Strepsidura*) *Marnochi*, and *Terebra plicifera* from Atascosa County. It appears not improbable that the *Cardita planicosta* frequently referred to by geologists is in reality an allied species, *C. Moorei*.

Immediately to the south of the Eocene, according to Loughridge, a belt of sandstone, extending completely across the State, and probably referable to the Grand Gulf Group (Miocene?), makes its appearance. Beginning at the lower part of Sabine County, it outcrops on the Trinity River near Trinity Station, in the county of the same name, where it forms a bluff some 100 feet in thickness, near Chapel Hill and Burton in Washington County, at La Grange in Fayette, where it also forms a bluff 100 feet in height, and at various points in De Witt, Live Oak (passing near Oakville) and Duval counties, reaching the Rio Grande at Rio Grande City. Buckley also mentions the existence of "hard siliceous limestones and sandstones," referable to the newer Tertiary series, in Washington and Fayette counties, which evidently form part of the series described by Loughridge. They are stated to be practically devoid of fossils, only a few specimens of a bivalve (*Meretrix*) having been found near the centre of Washington County.* The formation here referred to is covered all along the coast line by the deposits of the Port Hudson Group (post-Pliocene).

Tennessee.

The Tertiary formations of Tennessee, occupying a tract some 60–75 miles in width in the western part of the State, consist of variously colored sands and clays, and lignitic deposits, from which traces of zoogene fossils are for the most part absent. Plant remains, on the other hand, are sufficiently abundant, clearly indicating the conditions under which the deposits in question were laid down.

The following subdivisions are recognized by Safford,† although the upper and lower groups are but provisionally indicated:

3. Bluff Lignite.
2. Orange Sand, or La Grange Group.
1. Porter's Creek Group (oldest).

The Porter's Creek Group, with a stated development of 200 or 300 feet, is doubtless, as is suggested by Safford, the northern extension of the "Flatwoods" of Mississippi, constituting the base of Hilgard's "Northern Lignite." Casts of shells occur in some of the sandy rocks, but their bad state of preservation precludes the possibility of their determination. The belt of surface occupied by this group is along the line of the Memphis and Charleston Railroad about eight miles wide, narrowing towards the north. The outcrop of the Orange Sand, whose thickness is assumed to be about 600 feet, covers a tract some 40 miles in width, the beds dipping at a slight angle to the west.‡ Vegetable remains belonging to fourteen § or more species of

* Buckley, First Annual Report, p. 63. † "Geology of Tennessee," 1869, p. 422, *et seq.* ‡ Safford, *op. cit.*, p. 425.

§ *Quercus crassinervis. Q. Saffordi, Q. myrtifolia?, Q. Lyelli, Prunus Caroliniana, Fagus ferruginea, Elæagnus inæqualis, Andromeda vaccinifolia* (form related to), *A. dubia, Sapotacites Americanus, Salix? densinervis, Salix Worthenii, Cœnothus Meigsii, Juglans Saffordiana.*

plants have been described from the deposits of this group by Lesquereux, by whom they were considered to indicate a horizon more nearly Miocene than Eocene, but there can be but little doubt from the position of the beds containing them that they belong to the same period to which the greater part of the northern Mississippi lignite itself belongs—the lower Eocene. The Bluff Lignite, underlying the Quarternary gravels of the Mississippi Bluffs, consist in large part of a series of interstratified sands and clays, "characterized by the presence of well-marked beds of lignite." Its development appears to be at least 100 feet.

Illinois.

The Tertiary deposits of Arkansas and Tennessee are continued through the south-east and southwest extremities respectively of the States of Missouri and Kentucky into Illinois, where they form the head of the Mississippi embayment. The series, represented by variously colored sands and clays, and ferruginous conglomerates, has thus far been identified only in the southern part of the State (with a principal development in Pulaski County), but not improbably, as has been suggested by Worthen, marine or fluvio-marine deposits of the same age may occur considerably higher up the Mississippi valley.* A green marly sand, resembling in its lithological characters the Cretaceous greensand of New Jersey, constitutes a marked feature of the formation in Pulaski County, and from it have been obtained casts of fossils pertaining to the genera *Cucullæa* and *Turritella*.†

A thin bed of lignite is stated to underlie the formation along the edge of the Ohio at Caledonia, constituting in that vicinity the lowest visible member of the series.

NOTE *a*.—Since the preparation of the foregoing article, I am informed by Prof. Suess, of Vienna, that the lower limestone beds of the island of Malta, which were originally referred by Fuchs to the "Aquitanian" (Oligocene), and as the partial equivalents of the Sotzka beds of the Vienna basin, belong in reality to the "First Mediterranean." If this be the case, then the *Orbitoides Mantelli* beds of the island represent a newer horizon —lower Miocene—than they do in our own country and the West Indies. In material recently received from Florida I find great quantities of *Orbitoides ephippium* associated with the other forms.

b.—In the "Virginias," for February, 1882, and October, 1882, will be found detailed accounts, by Prof. W. M. Fontane and the late Prof. W. B. Rogers, of the 907-foot artesian boring at Fort Monroe, on the peninsula, about 6 miles to the east of Newport News.

*** In the accompanying map the Cretaceous exposures in the Tertiary area (North Carolina, South Carolina) have been, for convenience, omitted; likewise the exposures of the Eocene in the Miocene traets.

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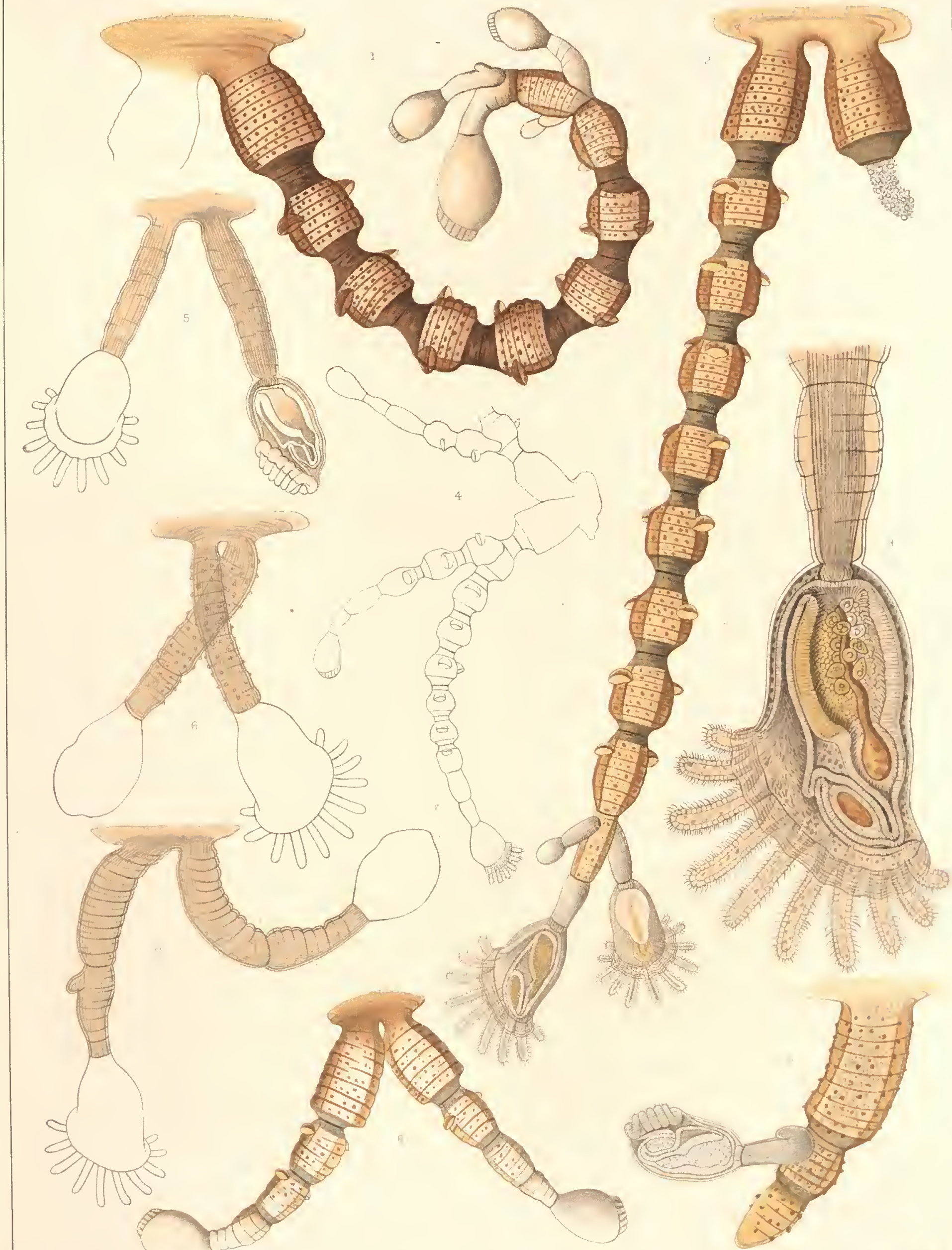
* "Geological Survey of Illinois," i, p. 46, 1866.

† Worthen, *op. cit.*, p. 45. The forms are here eonsidered to be specifically unidentifiable, but on p. 423, the *Turritella* is referred, although with doubt, to *T. Mortoni*, a distinctively lower Eocene fossil.



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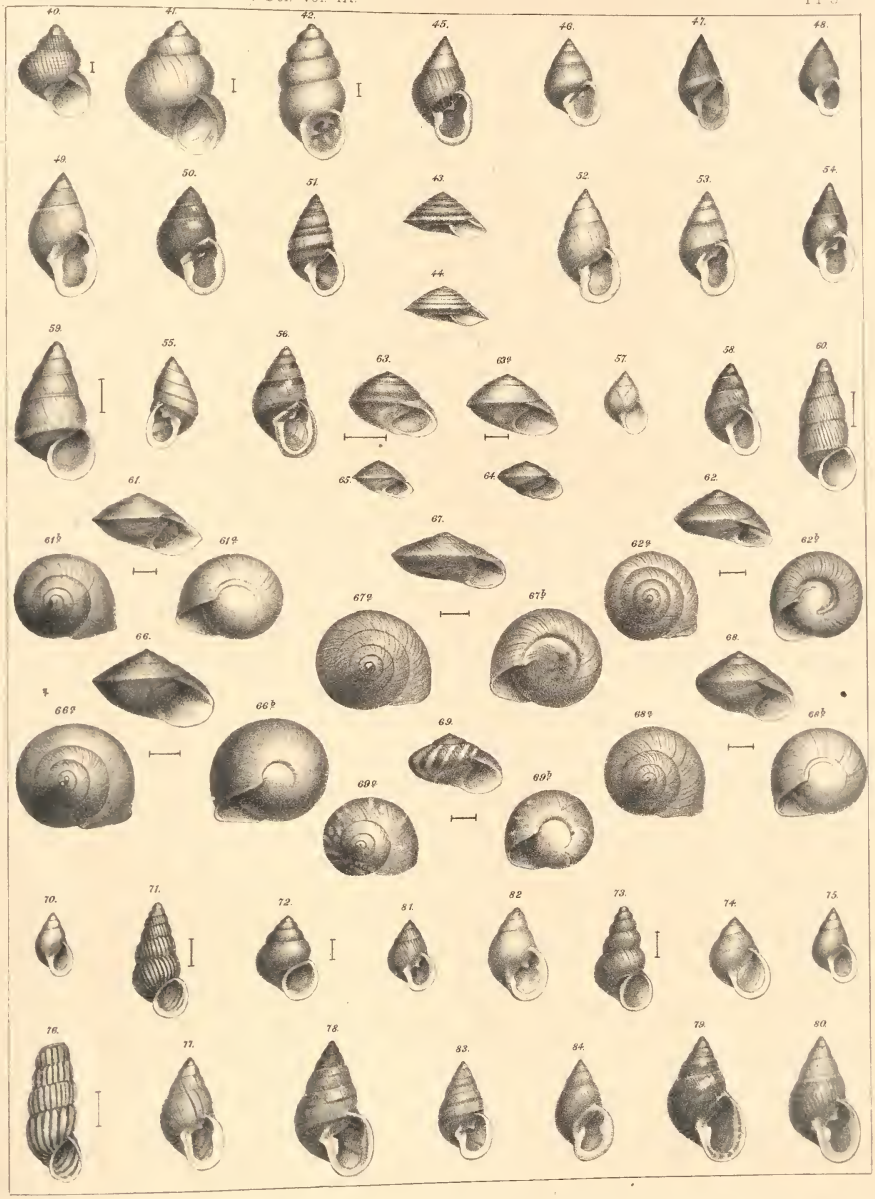

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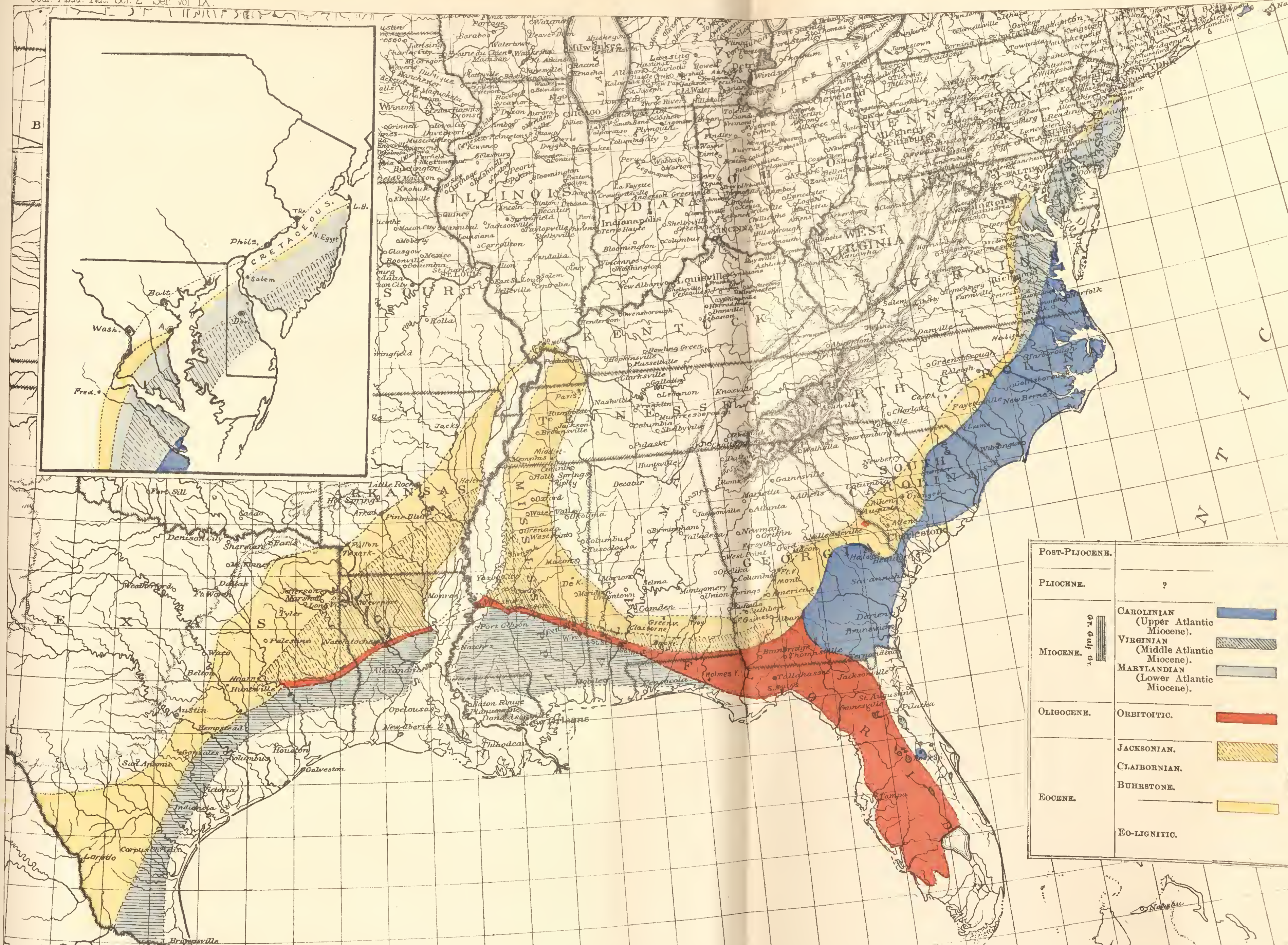

HEILPRIN ON TERTIARY GEOLOGY OF EASTERN AND SOUTHERN UNITED STATES.

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1888.

ON SOME NEW AND LITTLE KNOWN CREODONTS.

By W. B. Scott.

Genus MESONYX.

I. Mesonyx obtusidens.

The Princeton Scientific Expedition of 1886 had the good fortune to obtain at Twin Buttes, Wyoming, an unusually perfect skeleton of *Mesonyx obtusidens*, from which all the important characters of the genus may be made out. This will enable us to clear up some of the confusion which still prevails as to the early eocene flesh-eaters of North America. The few deficiencies in the chief specimen are nearly all supplied by other individuals from the same region. The only bones not represented in the collection are: (1) two sacral and (2) several caudal vertebræ, (3) the distal end of the femur, (4) the central, (5) the rudimentary 1st metacarpal, (6) the entocuneiform. A restoration may thus be made which offers very little opportunity for error (Pl. V).

The Skull.—This is the most remarkable part of this very peculiar animal; the exceedingly small brain capacity, (less even than in *Thylacynus*), the immense sagittal crest, the very long and wide zygomatic arches, the narrow and lofty occiput, and the great length of the muzzle, strike one at the first glance (Pl. VI.)

The *basi-occipital* is broad and flat, the *exoccipitals* very narrow, the condyles small and directed strongly outwards; the paroccipital processes are short and stout and arise very close to the condyles. The *supra-occipital* is very high, narrow and recurved, so that when the skull is in a horizontal position the summit of the occiput projects considerably beyond the condyles. The supra-occipital is shaped like a narrow lanceolate Gothic arch, and as a whole the occiput is in strong contrast to that of the Carnivora.

The base of the cranium is somewhat injured, so that it is difficult to make out the relationships of the *tympanic* and *periotic*. A very small and apparently undivided bulla is present.

The *basi-sphenoid* is likewise broad and flat; the *ali-sphenoids* small and apparently pierced by an ali-sphenoid canal. The *parietals* are very large, but comparatively little of them is applied to the wall of the brain cavity, the greater part going to the formation of the very high and thin sagittal crest, which gives much of its most curious physiognomy to the head. The appearance of this part of the skull is very similar to that of *Stypolophus* as shown by the figures of Professor Cope and M. Filhol, except that in this genus the brain case is much more capacious.

Owing to the exceedingly fragile condition of the pterygoids the matrix could not be removed from the posterior nares, so that the *pre-sphenoid* is concealed, nor could the limits of the *orbito-sphenoids* be satisfactorily made out. The *frontals* are very large. Posteriorly they are wedged in between the parietals by narrow processes and then widen rapidly to form the broad, nearly flat forehead. They arch over the eyes, forming the upper and part of the front boundary of the orbits. The post-orbital process is not very conspicuous.

The *lachrymal* is large and as in *Hyænodon*, *Thylacynus* and many Insectivora extends somewhat on the face. The foramen is single and just inside the orbit. The *malar* is long and slender, forming the entire lower boundary of the orbit, but extends very little on the face. It arches strongly outwards and, making a very long contact with the zygomatic process, passes as far back as the anterior edge of the glenoid fossa. The post-orbital process is very feebly indicated.

The *squamosal* forms the side wall of the cranium more extensively than the parietal. The zygomatic process is at first directed at right angles to the axis of the skull; this portion is massive and projects far outwards. The remaining part of the process is bent forwards at right angles to the first and is much more slender. Its upper surface is nearly straight, the lower arches strongly upwards. The glenoid fossa resembles that of *Arctocyon* with prominent pre-and post glenoid crests. As a whole the zygomatic arch is exceedingly wide and long, though rather slender; its upper edge is very nearly straight and the glenoid fossa with its massive support projects much below the level of the arch.

The *nasals* are very long and narrow. Posteriorly they are broad and just over the orbits are wedged in between the diverging frontals; narrowing rapidly, they pass forwards as slender splints to the nasial opening. The anterior ends are not emarginated, nor do they project far beyond the edges of the premaxillaries.

The *premaxillæ* are shaped much as in the dogs. The ascending ramus is thin; it arches around the nose, and reaching the nasal, sends back a tapering process which is in contact with the nasal for about an inch. The alveolar portion is stouter; the spine is well developed, and the incisive foramina are long narrow ovals.

The *maxillæ* are very large bones, forming almost the whole of the face. The two bones are not far from parallel, as the molar series do not diverge much. The large infraorbital foramen is placed above the last premolar. The palatine plates are broad; they show no vacuities.

The palatines are large bones, extending forward to the 1st molar, joining the plates of the maxillæ by a rounded suture. The posterior palatine foramina are very small. Along the front margin of the posterior nares the palatines are thickened and in the middle there is a short stout spine. They are also produced far back to enclose the unusually long and deep posterior nares. The limits of the *pterygoids* are not very clear. These bones are long and high, but as their margins are somewhat broken the presence or absence of hamular processes cannot be stated.

The *mandible* is very long and rather shallow; both the alveolar and lower borders are strongly curved antero-posteriorly; the condyle is transverse, strongly convex and placed very low, considerably below the level of the teeth. The angle is prolonged into a stout hook, much like that of *Stypolophus*; the coronoid process is very broad but not high, and rises obliquely from the horizontal ramus. The masseteric fossa is large but not deep; not nearly so marked as in *Hyænodon*. The symphysis is much shorter and broader than in *M. lanius*. The mandible of *Pachyæna ossifraga* is very different, aside from its greater size. The angle is not prolonged into a hook, the condyle is placed higher, the coronoid notch is wider, and the symphysis is much longer.

The *Brain*. Owing to the thinness and fragility of the bones, a cranial cast could not be attempted, but the partial exposure of the natural cast allows some facts to be made out. The cerebral hemispheres are very small, but show some convolutions; the cerebellum is relatively large, is lodged in a distinct fossa, separated from the cerebrum by a tentorium.

Dentition. Professor Cope has described the dentition in part, but as this is the first specimen in which nearly all the teeth have been found in place it will be necessary to give some account of them.

(1) *Upper Jaw*. The median incisor is small, has a very compressed fang and a simple crown; the second is somewhat larger and the outer very much larger, with a long pointed crown, worn on its external side by the lower canine. A considerable diastema exists between the outer incisor and the canine. The latter is a powerful tooth, in size and proportions much like that of the black bear, though somewhat more compressed; it is very different in appearance from that of *M. lanius*. The 1st premolar follows immediately after the canine without diastema, and in this differs from *Pachyæna* which shows diastemata both before and behind the 1st premolar; it has two fangs and its crown is small and compressed, with the merest rudiment of a posterior tubercle. After a small interval, which does not deserve the name of a diastema, comes the 2nd premolar, which is much larger than the first; it is conical also, but has a more developed heel and a distinct cingulum. An interval occurs between the 2nd and 3rd premolars, about equal to that between the 1st and 2nd. The 3rd premolar is larger than the 2nd and the heel is now almost as high as the main cusp; there is also a marked increase in thickness; a small internal tubercle appears opposite the heel and a very small anterior basal cusp is present. The homologies of the succeeding tooth are somewhat doubtful; I am inclined however, to consider it as the 4th premolar for the following reasons: (1) In the flesh-eaters, both creodonts and carnivores, the 3rd molar is usually the first tooth to disappear; (2) the tooth in ques-

tion is not quite like the molars in pattern, but altogether like the 4th premolar of *Pachyæna*; (3) the last molar of *Mesonyx* is very different from the 3rd molar of *Pachyæna* and entirely like the 2nd molar. It seems reasonable therefore to infer that the missing tooth in *Mesonyx* is the 3rd molar. This 4th premolar, as I shall call it, resembles the molars in having a large internal cusp, but differs from them in the conformation of the outer part of the crown, which is not so plainly divisible into two cusps; the cingulum is confined to the outer face of the crown. The molars are essentially alike, though the first has a somewhat greater antero-posterior and proportionately smaller transverse diameter; there are two external cusps, with a cingulum on the outer side, and anterior and posterior basal tubercles (the posterior is not present on the 2nd molar); the internal cusp is very large and placed opposite the antero-external one.

Lower Jaw. The incisors are very small and simple with compressed fangs and without cingulum. The canine is bear-like and is somewhat everted. The 1st premolar is missing from the specimen; the 2nd has two fangs, a small conical crown with rudimentary heel. The 3rd and 4th are essentially like the molars, consisting of a thick retroverted conical cusp and heavy blade-like heel; the anterior basal tubercle appears only on the 4th. The molars decrease in size posteriorly; the main cusp is larger and thicker than on the premolars; on the 3rd molar the heel is much reduced and the anterior basal tubercle rudimentary. These molars differ from those of *Pachyæna* in the much greater development of the heel and the reduction of the anterior basal tubercle. In *Pachyæna* the tubercle and heel are about the same size, giving the tooth a very different appearance. (See Cope, Pl. XXVIII *b*, Fig. 1). All the molars of *Mesonyx* are worn at the tips, so that they have become more and more blunted with advancing age.

M. obtusidens differs from *M. lanius* chiefly in the canines and incisors; the former are much flattened and worn on the sides, the latter seem to be entirely absent from the lower jaw, though this is not certainly determined, the shape of the symphysis is also very different, and more perfect specimens than have yet been obtained will very probably necessitate the revival of the genus *Synoplotherium*, which Professor Cope considers a synonym of *Mesonyx*.

The Vertebral Column.—The *atlas* is remarkable for the smallness of the transverse processes, which are nearly straight in direction and produced very little behind the faces for the axis. They are perforated for the vertebral artery and are deeply emarginated on the posterior edge and produce an appearance very unlike that in the typical Carnivora and rather like that in *Thylacynus*. The superior arch is broad, and perforated for the 1st spinal nerves; the spine is a mere roughness. The inferior arch is slender and the condyles small.

The *axis* is very peculiar. The centrum is long and depressed, with a strong keel, and long very stout cylindrical odontoid. The atlanteal faces are oval, and rise high up around the neural canal, which emarginates them. The postzygapophyses are prominent and directed but slightly outwards. The neural spine is very curious. It is produced but little in front of the pedicels, and the upper edge rises steeply from the front until it forms a thick, blunt spine, ending slightly behind the centrum. This is very different from the hatchet-shaped structure of the ordinary Carnivora and Insectivora, but it is approached in *Mydaus* and *Meles*.

The remaining *cervicals* are not especially remarkable. The centra are long, slender and somewhat opisthocœlous, with faces oblique to the long axis of the centrum. On some there is a strong hypapophysial keel expanding behind into a pair of rugose processes. The cervical spines are unusually long and indicate muscles of great size.

The *dorsal* vertebræ, 14 in number, are remarkable in many ways. In the anterior region, the centra are small, somewhat opisthocœlous and of sub-triangular section; the spines are exceedingly long and stout. These decrease rapidly as we pass backwards until on the 11th or anticlinal vertebra the spine is hardly a third as long as on the 1st. Behind the 11th the spines point forward, are short and compressed and occupy the whole length of the neural arch, as in the lumbar region. The centra in the posterior region are much larger and heavier than in the anterior and are considerably depressed. The transverse processes are short and heavy and, except on the 13th and 14th, with large round faces for the tubercles of the ribs. The zygapophyses in the anterior region, are long, narrow ovals, are flat and present directly upwards and downwards; from the 10th the postzygapophyses becomes cylindrical, and the prezygapophyses of the remaining vertebræ are deeply concave and have strong metapophyses; anapophyses are also present on some. The posterior dorsals of *Pachyæna* differ from these chiefly in the absence of metapophyses and the much greater obliquity of the faces. The disparity in the length of the limbs would necessitate a strongly arched back.

The *lumbar* vertebræ, numbering six, are very large with broad, depressed, and nearly plane centra, which are contracted in the middle. The spines are long, broad and thin, inclining forward; the transverse processes are very long, slender, and curved forwards and downwards. The zygapophyses are like those of the posterior dorsals, with prominent metapophyses; anapophyses are absent, except perhaps on the 1st. As Professor Cope has pointed out, the articulations of these vertebræ show a greater degree of specialization than is found in any living carnivore.

The *sacrals* are not all preserved. They probably were three in number. The first has a short and flat centrum and short expansions for the ilium; the last has a low spine and small rounded post-zygapophyses.

The *caudal* vertebræ, of which some 14 are preserved, indicate a very long tail, much as in the leopard. The anterior vertebræ are short and flat with well developed zygapophyses and short backwardly directed transverse processes. Passing backwards, the centra rapidly elongate and the processes become rudimentary. The distal end of the tail is composed of numerous very slender joints. Strong chevron bones are found under some of the anterior vertebræ.

THE RIBS.—The ribs are like those of the bears; the anterior ones, especially the first, are remarkably short and flat; about the 7th they become slender and oval in section and from the 9th decrease in length. Heads and tubercles are well developed except on the last two or three, when the tubercles become rudimentary. The last rib is very slender.

THE STERNUM.—Of this bone only one complete and parts of two other segments are preserved, enough to show that the sternum was comparatively broad and flat, slightly concave on the upper surface and convex on the lower, very much as in *Arctictis*. The segments are also of rather unusual length.

THE FORE-LIMB.—The *scapula* is in general much like that of *Hyæna* and the cats. The glenoid cavity is deeply concave antero-posteriorly, but rather shallow transversely; the coracoid is very small. The neck is constricted and very narrow, and the coraco-scapular notch correspondingly deep. The coracoid border is curved upwards and backwards from the edge of the notch, enclosing a large prescapular fossa. The supra-scapular border is thickened, rugose, nearly straight, and inclined somewhat downwards. The glenoid border is also nearly straight, but with an unusual obliquity. The spine is prominent, ending in a stout curved acromion, which does not project over the glenoid cavity. The pre and post-scapular fossa are of very nearly equal extent. Compared with the other limb-bones, the scapula is very long, longer than the radius, which is a rare proportion among the Carnivora.

The *humerus* is short and not very stout, and in general resembles that of *Hyæna*. The head is well rounded, and the neck quite distinct; the outer tuberosity projects but slightly above the head, and is less prominent than in the hyæna, but more distinctly divided into two parts; the inner tuberosity is very small and the bicipital groove broad and shallow. The shaft is strong above and rather slender below the middle, and is nearly smooth, the ridges for muscular attachment being inconspicuous. The deltoid ridge is low and rough, the supinator somewhat more prominent, but not rugose. The external condyle is small, the internal quite large; the anconeal fossa is very deep and perforates the bone. The trochlea is quite like that of the hyæna, with somewhat more prominent convex surface for the radius and internally a strong downward projection for the ulna. This humerus differs from that of *M. lanius* in the greater prominence of the internal condyle and radically from that of *Pachyæna ossifraga*. It is very much longer, the muscular ridges are far less conspicuous, there is no supracondylar foramen, and the trochlea is of quite a different shape. The *radius* is proportionately short, much shorter than in most carnivora. The proximal end is broad, and occupying most of the humeral trochlea, could have had no motion of supination. The shaft is cylindrical and strongly bowed; the distal end is heavy, shows an external facet for the ulna and two distal concave faces for the scaphoid and lunar.

In *Pachyæna* the radius is relatively shorter, more flattened, and the facets for the scaphoid and lunar are not separated.

The *ulna* is slender with a subtrihedral curved shaft, and long very stout olecrannon. The distal end is a narrow convex surface for the cuneiform. In *Pachyæna* the ulna is straighter, the olecrannon not so broad, and the distal end acuminate.

The *carpus* (Pl. VII.) is of extraordinary interest, and is distinctly like that of the Insectivora. The *scaphoid*, which is separate from the lunar, has very little depth; the tuberosity is smaller than in the Carnivora; the surface for the radius narrow and convex. Distally there are three facets; (in *M. lanius* those for the trapezium and trapezoid are confluent), a small internal one for the trapezium, a larger median one for the trapezoid, and externally a narrow and deeply excavated one, which Professor Cope considers to be for the magnum, but which is really for the central. The *lunar* has a very convex upper surface, the radial articulation extending over the front face. The distal end is wedge-shaped, formed by two deeply concave facets, a larger one for the magnum and a smaller one for the cuneiform. Professor Cope's restoration of this bone (Tertiary Vertebr. Pl. XXIX, Fig. 3) is much too large and entirely incorrect in shape.

The *cuneiform* is very unlike that of the Carnivora. The ulnar surface is narrow and concave; posteriorly there is a broad face for the pisiform, which rests against and not upon the cuneiform. The unciform surface is also concave.

The *pisiform* is very stout and has a heavy knob at the distal end. The ulnar facet is reversed D shaped, that for the cuneiform more quadrate in outline, the two meeting at an angle of about 45° The *trapezium* is high and narrow, and has four articular surfaces, one small and round for the scaphoid, a larger concave facet joins the trapezoid; beneath is a flat quadrate surface for metacarpal II, and distally is a very small saddle-shaped facet for the rudimentary metacarpal I. The *trapezoid* is a stout bone, broader in front than behind. It rises considerably above the level of the magnum. Its metacarpal is the stoutest of all.

The *magnum* is the smallest bone in the carpus, except perhaps the central; the vertical diameter is its least dimension, and is much exceeded by the unciform and trapezoid. The magnum possesses five articular surfaces, for the lunar, central, trapezoid, unciform and metacarpals II and III. The upper facets are strongly convex, that for the lunar is the larger, that for the central very narrow. The articulation with metacarpal II is somewhat larger than with III.

The *central*. I have spoken confidently of the presence of this element, although it is not preserved in any specimen I have yet seen. Its existence is however made very clear by the following facts: (1) The scaphoid is prevented from reaching the magnum by the height of the trapezoid and by the mode of articulation with the lunar. (2) On the distal face of the scaphoid is a facet which is not occupied by the trapezium or trapezoid. (3) The lunar leaves a proximal facet of the magnum untouched, corresponding to that on the scaphoid; the two, however, cannot possibly come in contact. (4) When the carpal bones are put in their natural position, a vacancy is seen to occur between the scaphoid above, the lunar and trapezoid at the sides, and the magnum below. This is exactly the position which the central should occupy, and by no other assumption can the relations of the other carpals be explained.

The *unciform* is the largest of the elements. The proximal surface is mostly occupied by the cuneiform, but rising above this is a narrow, convex, and oblique facet for the lunar. A considerable facet for metacarpal III is to be seen below the magnum, and distally are two broad and somewhat concave surfaces for metacarpals IV and V.

The *metacarpals*, as Professor Cope has remarked, resemble those of the hyæna, though they are shorter and more perfectly interlocked; II and IV are short and stout, III and IV longer and much more slender. No. II overlaps III and sends a strong process to the magnum, III overlaps IV and sends a similar process to the unciform. No. IV has no such process, but on its external side is a cavity which receives a projection from V. Professor Cope's figure of the metacarpals of *M. lanius* is incorrectly drawn. He has kindly allowed me to examine his type specimen and it agrees with that here described. The metacarpals of *Pachyæna* are shorter, stouter, and not so much interlocked as in *Mesonyx*; indeed the latter shows a degree of interlocking which is more pronounced than in any modern carnivore except the cats.

The proximal *phalanges* of the lateral digits are stout, depressed and curved, those of the median digits long and more slender; the same statement holds good of the second row. In both series the distal articular surface is reflected on the upper face of the bone, more so than in the hyæna. The ungual phalanges, as long ago pointed out by Professor Cope, are very peculiar and remotely like those of the seals. They are rather more like small hoofs than claws, are broad, depressed and deeply cleft at the end. A wedge-shaped thickening passes along the under surface giving the bone greater strength.

The Hind Limb. The *pelvis* is most like that of the bears; the ilium and ischium are in the same straight line and of about equal length. The former is stout and somewhat everted anteriorly, with concave iliac surface and a tubercle representing the anterior inferior spine. The ischium is a stout trihedral rod expanding posteriorly into a very large but not thick tuberosity. The pubis is short and heavy, meeting its fellow in a long symphysis. The obturator foramen is a long narrow oval. The acetabulum is rather small.

Of the *femur* only the proximal half is preserved. Except for the presence of the 3rd trochanter, it resembles the femur of the Carnivora. The great trochanter is rather small and has a rugose edge; the shaft is rounded and slender. "The rotular groove is narrow and elevated, the inner margin a little higher. The condyles are rather narrow, the inner with less transverse and antero-posterior extent, and separated by a wide deep groove. The patella is narrow, thick and truncate at one end."—(Cope).

The *tibia* is in size and shape like that of the hyæna, but is considerably longer than the radius. The femoral faces are separated by a prominent spine. The cnemial crest is heavy and conspicuous, extending far down the shaft. Above the shaft is large and of trihedral section, below more slender and rounded. The distal end shows a heavy internal malleolus and two quite deep astragalar facets separated by a low but distinct ridge. This is quite as in the digitigrade Carnivora and quite different from the ordinary creodonts in which the astragalar face is nearly flat.

The *fibula* is very slender. Its proximal end is applied to the under surface of a projection of the tibia; distally it expands into a very large external malleolus.

The *tarsus*. The *astragalus* is well known from Professor Cope's description. It is remarkable for the deeply grooved trochlea and the articulation with the cuboid, which, as Mr. Wortman has shown, is approximated in some of the Arctoidea. The neck is long, the navicular face narrow and strongly convex. As a whole the bone is very different from that of the Creodonta ordinarily, and most like that of the digitigrade Carnivora. The same is true of the *calcaneum*, which is long and strong. The upper condyle is prominent and sharply rounded, the sustentaculum large, and is removed further from the distal end than in the Arctoidea. The distal end has two articular faces, a broad one for the cuboid, and a narrow one on the inner edge for the astragalus, giving three distinct articulations with that bone, a peculiarity which I have not found in any carnivore. The calcaneum and astragalus of *Pachyæna* are in essentials like those of *Mesonyx*, though with some minor differences. The *cuboid* is very long and heavy. At an acute angle with the broad calcaneal facet is a narrow astragalar one. Distally the facets for metatarsals IV and V may be distinguished, that for the latter is very small. On the internal face of the cuboid is a projection which passes between the navicular and external cuneiform. The *navicular* is a narrow and shallow bone, with its astragalar facet concave in both directions. In vertical height it is scarcely more than $\frac{1}{3}$ that of the cuboid. Distally three small facets for the cuneiforms are visible. The *external cuneiform* is very high and narrow, articulating with the navicular by a small rounded surface and with the ledge of the cuboid. The *middle cuneiform* is much smaller than the external. A small convex head fits into a depression in the navicular, and distally there is a narrow wedge-shaped surface for metatarsal II.

The *internal cuneiform* is missing, but the navicular facet shows it to have been very small. It could not have supported a functional digit.

The *metatarsals* are longer and much more slender than the metacarpals, but are arranged in much the same way, III and IV longer, II and V shorter. The interlocking is but slight, II rising above the level of the other three on account of the shortness of the middle cuneiform. Nos. V and IV have an inwardly directed projection which fits into a corresponding cavity in the adjacent metatarsal. Nos. II and III are not interlocked at all.

The *phalanges* are like those of the fore-foot, but longer and more slender.

As a whole, the high and narrow pes is very different from that of the plantigrade and much like that of the digitigrade Carnivora, especially *Hyæna*, to which the resemblance is very close, even in details.

(What I believe to be the distal end of the *os penis* is represented in the specimen. It is curved upwards and ends in a small knob, resembling the corresponding bone in some of the *Mustelidæ*.)

Restoration.—The skeleton of *Mesonyx* as a whole is very curiously proportioned. The head is very large, the trunk very long, with prominent spines in the dorsal region, the flanks slender, and the tail long and cat-like. The thorax is shallow and compressed. The limbs are very short and the feet especially weak. With a body as long as that of a full-grown black bear, the animal did not stand as high from the ground as a large dog, and compared with the bear the limbs were not muscular, not more than in the hyæna. When alive, the creature must have had a very grotesque appearance. Indeed its peculiarity might excite the suspicion that the drawing was incorrect, but the specimen is so perfect that the only room for question is as to the length of the femur and of a few ribs, and the exact number of joints in the tail. Possibly also the animal possessed a greater number of dorso-lumbar vertebræ; but this is very unlikely, as those preserved seem to indicate an unbroken series, without any perceptible gaps. It is also, perhaps, a question as to whether the animal was plantigrade, as Professor Cope believes, or digitigrade as I have represented it. My reasons for this course are: (1) The length and narrowness of the feet, which are in sharp contrast to the feet of the plantigrades; (2) the reduction in the digits, which seems to have gone as far as in any living carnivore; (3) the extraordinarily perfect interlocking of the metacarpals, which is not approached in the Arctoidea and excelled only in the cats; (4) the very long narrow tarsus and character of the astragalar trochlea; (5) the very close general resemblance to the feet of *Hyæna*. With the possible exception of *Pachyæna* no known creodont can show such a specialized foot structure as *Mesonyx*.

Affinities.—The relations of the *Mesonychidæ* to any other group are very obscure. From the study of imperfect specimens I was formerly led to consider them closely allied to *Hyænodon*, but as Professor Cope has shown, the resemblance in the dentition is rather a superficial than a fundamental one, and the limbs are very different in the two forms. *Hyænodon* has five functional digits in the manus, with a short, broad plantigrade foot. *Mesonyx* cannot be regarded as an ancestor of *Hyænodon*, as the latter is in many respects more primitive than the former.

In *Mesonyx* we are presented with a most curious assemblage of characters.

Together with an exceedingly small brain, and a primitive type of dentition and carpus, we find associated a highly differentiated metacarpus and tarsus, a reduction of digits like that of modern carnivores, and finally a mode of articulation in the lumbar and posterior dorsal vertebræ more perfect than in any existing carnivore. I cannot confirm Professor Cope's and Mr. Wortman's suggestion of a relationship between *Mesonyx* and the seals. A certain similarity in the claws and teeth is undoubtedly present, but the characters of the skull, brain, vertebræ and limbs are altogether different. The ancestry of the seals is more probably to be looked for in the Bridger genus *Megencephalon*. Altogether, then, it would seem that *Mesonyx* and *Pachyæna* form highly specialized side branches of the Creodonta which died out without successors. No living animal seems to stand in direct relationship with these extinct genera.

HISTORY.—The genera *Mesonyx* and *Synoplotherium* were established by Professor Cope in 1872 upon specimens from the Bridger Eocene, *Pachyæna* in 1874 to receive certain species from the Wahsatch of New Mexico. Subsequently Professor Cope concluded that all three forms belonged to the same genus. But as we have seen, *Mesonyx* is very different from *Pachyæna*, and more perfect specimens will very probably show that *Synoplotherium* is also distinct. But this question cannot be decided at present.

Mesonyx, Cope 1872 (=? *Synoplotherium*, Cope 1872,) *Mesonychidæ* with the dental formula: $I\frac{3-3}{2-2}$, $C\frac{1-1}{1-1}$, Pm. $\frac{4-4}{4-4}$ $M\frac{2-2}{3-3} = 40$; no diastemata behind canine; fore and hind limbs of nearly equal length, metapodials elongate, and animal probably digitigrade.

Pachyæna, Cope 1874. Dental formula: $I\frac{3-3}{2-2}$, $C\frac{1-1}{1-1}$, Pm. $\frac{4-4}{4-4}$, $M\frac{3-3}{3-3} = 42$; diastemata in front of and behind 1st premolar; hind limbs much longer than fore limbs; metapodials short, and animal probably plantigrade.

The family *Mesonychidæ* may be defined as: Creodonta with trochlear ankle joint; "molar teeth in both jaws consisting of conic tubercles and heels; none sectorial; a preglenoid crest." (Cope.)

So far as is at present known, *Mesonyx* seems to be confined to the Bridger and Uinta formations, and *Pachyæna* to the Wahsatch.

MEASUREMENTS.

	MESONYX OBTUSIDENS	HYÆNODON CRUENTUS.
	M.	M.
Length of skull (along base)	.279	.227
" cranium	.125	.114
" face	.154	.113
Breadth across zygomatic arches	.165	——
" of forehead	.080	.075
" of cranium (greatest)	.055	.054

MEASUREMENTS.

		MESONYX OBTUSIDENS.	HYÆNODON CRUENTUS.
		M.	M.
Height of occiput		.088	—
Depth of face (from above orbits)		.073	.068
Length of mandible (from condyle)		.225	.187
Height of coronoid		.087 (?)	—
Depth of mandible (below m. 3		.050	.038
" " m. 1		.037	.033
" " pm. 2		.037	.031
Length of symphysis		—	.067
Diameter 3rd incisor (long.)	Upper Jaw.	.009	.005
" " " (trans.)		.008	.004
Height 3rd incisor.	Upper Jaw.	.010	—
Diameter canine (long)	"	.019	.013
" " (trans.)	"	.013	.011
Height "	"	.038	.032
Length molar series	"	.098	.108
" premolar series	"	.067	.067
" true molar "	"	.030	.040
Length[1] premolar 1	"	.010	.012
Breadth " "	"	.006	.006
Height " "	"	.008	.008
Length " 2	"	.015	.015
Breadth " "	"	.008	.008
Height " "	"	.010	.014
Length " 3	"	.016	.018
Breadth " "	"	.008	.010
Height " "	"	.008	.013
Length " 4	"	.015	.018
Breadth " "	"	.013	.012
Height " "	"	.010	.017
Length molar 1	"	.017	.018
Breadth " "	"	.016	.008
Height " "	"	.009	.012
Length " 2	"	.013	.023
Breadth " "	"	.017	.012
Height " "	"	.008	.018
Diameter of canine (long.)	Lower Jaw	.016	.015
" " (trans.)	"	.013	.011
Height "	"	.027	.032
Length molar series	"	.108 (?)	.117
" premolar series	"	.057 (?)	.062
" true molar "	"	.051	.055
Length premolar 2	"	.013	.014
Breadth " "	"	.006	---
Height " "	"	.009	—
Length " 3	"	.018	.017
Breadth " "	"	.008	.008
Height " "	"	.013	.013
Length " 4	"	.019	.017
Breadth " "	"	.008	.010
Height " "	"	.012	.016
Length molar 1	"	.019	.012
Breadth " "	"	.009	.007
Height " "	"	.015	.009
Length " 2	"	.018	.018
Breadth " "	"	.008	.008
Height " "	"	.015	.013
Length " 3	"	.014	.025
Breadth " "	"	.007	.010
Height " "	"	.010	.014

[1] *Length* in tooth measurements is used in the sense of antero-posterior diameter.

MEASUREMENTS.

	Mesonyx obtusidens.	Hyænodon horridus.
	M.	M.
Atlas, breadth	.100	.102
Axis, length, centrum	.041	.039
" " odontoid	.017	——
" diameter spine (antero-posterior)	.075	——
" length transverse process	.023	.036
" breadth atlanteal facets	.041	.040
6th cervical, length centrum	.032	.030
" " height "	.018	.020
" " " spine	.053	——
1st dorsal, length centrum	.027	.024
" " height "	.019	.020
" " " spine	.083	——
" " diameter spine	.019	.018
" " length transverse process	.020	.020
" " diameter " "	.014	.018
7th " length centrum	.025	(6th) .021
" " height "	.016	" .018
" " " spine	.049	" ——
" " diameter "	.017	" .017
2nd lumbar, length centrum	.029	.036
" " height "	.016	.021
" " breadth "	.025	.032
" " height spine	.034	——
" " diameter "	.026	——
6th lumbar, length centrum	.032	.032
" " height "	.017	.018
" " breadth "	.025	.025
" " height spine	.043	.052
" " diameter "	.024	.022
" " length transverse process	.049	(3rd) .046
Sacrum, length	——	.071
1st sacral, breadth (incl. pleurapophyses)	.046 (?)	.059
2nd caudal, length	.024	——
12th (?) " "	.039	——
Last " "	.011	——
3rd (?) sternal segment, length	.045	——
" " " breadth (anterior edge)	.025	——
Scapula, height	.167	——
" greatest breadth	.094	——
" height acromion	.026	——
" diameter glenoid cavity	.032	——
Humerus, length	.194	200 (?)
" diameter of head (ant. post.)	.036	——
" breadth of trochlea	.027	.031
Ulna, length	.207	.200
" " olecranon	.048	.047
" breadth trochlea	.024	.026
" " distal end	.015	.016
Radius, length	.160	.150
" breadth proximal end	.023	.026
" " distal end	.024	.022
Carpus, breadth	.038	.043
" height	.021	.021
Pisiform, length,	.025	.027
" diameter of free end (vertical),	.016	.017
Metacarpal I, length,	——	.034
" " breadth, proximal end,	——	.012
" II, length,	.062	.056
" " breadth " "	.014	.014
" III, length,	.070	.066
" " breadth, " "	.011	——

MEASUREMENTS.

	Mesonyx obtusidens.	Hyænodon horridus.
	M.	M.
Metacarpal IV, length,	.065	.064
" " breadth,	.010	.012
" V, length,	.050	.039
" " breadth,	.014	.009
Phalanx, length, proximal (lateral digit),	.023	.019
" " median, " "	.012	——
" " ungual, " "	.016	.020
Pelvis, length,	.205	——
Ilium, length,	.115	——
" width (greatest),	.046	.040
Ischium, length,	.090	——
Acetabulum, diameter,	.027	——
Tibia, length,	.205	——
" breadth proximal end,	.042	——
" " distal "	.025	——
Fibula, length,	.191	——
" breadth proximal end,	.011	——
" " distal "	.017	——
Tarsus, height (from astragalus),	.046	——
" breadth,	.039	——
Calcaneum, length,	.056	——
Astragalus, "	.031	——
" breadth,	.018	——
Cuboid, length,	.013	——
Metatarsal III, length,	.079 (?)	——
" IV, "	.076 (?)	——
" V, "	.068	——
Cerebral hemispheres, length,	——	.062
" " greatest breadth,	——	.054
Olfactory lobes, length,	——	.024
" " breadth,	——	.040
Cerebellum, breadth,	——	.064

(Measurements marked (?) are approximate only.)

II. Mesonyx (?) Uintensis, sp. nov.

The first specimens of flesh-eaters known from the Uinta formation are portions of three individuals collected by the Princeton Expedition of 1886. One of these, consisting of an incisor, portions of a canine, one upper and two lower premolars and three lower molars, and portions of the mandible, is doubtfully referred to *Mesonyx*, and differs from all known species in its very much greater size, and in the reduction of the anterior tubercle of the molars. The incisor is peculiar and consists of a broad and rounded simple crown; it is of large size and contrasts strongly with the incisors of the Bridger species. The canine is very large; the upper premolar differs from the corresponding tooth of the Bridger species only in size. The lower premolars are much smaller than the molars and are composed of a compressed cone with anterior and posterior basal cusps; the posterior cusp is much less developed than in the other species of *Mesonyx*, thus making a much greater difference in shape between the molars and premolars. In the Bridger species all of the inferior molar series are essentially alike. The molars are very large and consist of two lobes, of which the anterior is a heavy, compressed and backwardly directed cone, and the posterior is a much lower trenchant heel, convex externally and concave internally. The attrition takes place on the summits and not on the sides of the lobes, so that they become more and more blunt with age. The ordinal arrangement of these teeth cannot be certainly determined, as they are all detached, but judging from the amount of wear, the first is the largest and the third the smallest, though there is much less difference in this respect than in the other species of the genus. The anterior basal tubercle is small on the first, still more reduced on the second and entirely absent from the third. This reduction gives the molars a somewhat different appearance from that seen in the species from the Bridger. The mandibular condyle differs in no respect except size from that of the other species.

I have referred this animal to *Mesonyx*, because the parts preserved do not show any differences of generic value. But in view of the character of the incisor and premolar teeth, it is quite probable that more perfect specimens will necessitate the formation of a new genus for its reception. At all events it certainly is a member of the *Mesonychidæ* and would seem to be the last variation which occurred before the extinction of this peculiar type.

MEASUREMENTS.

	M.
Diameter of incisor (fore and aft) . .	.011
" " (transverse) . .	.011
Length of lower premolar (1st ?) . .	.014
" " " (2nd ?) . .	.018
Length 1st lower molar	.031
Thickness " "	.015
Length 2nd "	.029
Thickness 2nd "	.015
Length 3rd "	.028
Thickness 3rd "	.012
Transverse diameter mandibular condyle .	.037

Genus DIDYMICTIS.

III. DIDYMICTIS ALTIDENS, COPE.

The *Miacidæ* approach nearer to the true carnivores than do any other creodonts, and consequently even very imperfect specimens are worthy of careful description. A fragmentary skeleton of *Didymictis altidens* obtained by the Princeton Expedition of 1884 in the Big-Horn basin of Wyoming (Wasatch formation) will serve to shed some additional light upon the characteristics of this family.

With regard to the dentition I can add nothing to Professor's Cope's account except to say that lower incisors were very probably present, as is shown by a loose tooth occurring with this specimen ; it is very small and has a simple crown and strongly curved fang, but no cingulum. The number of lower incisors cannot be made out, but as the space between the approximated canines is much reduced, it seems probable that not more than two were present in each ramus.

Vertibræ from nearly all the regions are represented in the specimen. The atlas is viverrine in character; the transverse processes are moderately expanded, rather more so than in the *Mustelidæ* and less than in the *Canidæ*, and perforated for the vertebral artery; the anterior condyles are quite deep, the neural arch broad and stout and the inferior arch slender. The axis has a short conical odontoid process; the centrum is broad, depressed and strongly keeled; the atlanteal faces are transversely directed and not emarginated by the neural canal, as in *Mesonyx*; the post-zygapophyses are placed low on the arch. The spine is missing from the specimen. The dorsal vertebræ have very small centra, which are subtriangular in section and have nearly flat faces. No processes are preserved on any of them. The lumbars are of particular interest as showing the typical creodont structure of concave prezygapophyses interlocking strongly with the sub-cylindrical postzygapophyses. The metapophyses are inconspicuous and the anapophyses small. No vertebræ from the sacral or caudal region are preserved in the specimen.

A fairly complete account of the fore-limb may be given, as portions of the scapula, humerus, ulna, radius and manus are represented. Of the *scapula* only the distal end is preserved, enough, however, to show a broad shallow glenoid cavity and stout coracoid hook; the spine commences very far back from the glenoid cavity and probably the acromion, if present at all, did not project over the cavity. The *humerus* is quite viverrine in character, and in a less degree like that of some of the *Mustelidæ*, but stouter; the head is flattened, the tuberosities low and the bicipital groove wide; the shaft is strongly curved and the very prominent deltoid ridge runs far down; an epitrochlear foramen is present. The *ulna* is peculiar for the great length of the olecranon, much exceeding that found in the recent carnivores. This would seem to be a character very prevalent among the creodonts, as well as certain insectivores, e. g., *Centetes*. The sigmoid notch is deep, but the humeral facet is small—most of the humeral trochlea being occupied by the radius; the shaft is very broad, rounded on the internal surface and channelled on the external; the distal end is expanded, but unfortunately the articular face is broken off. Of the *radius* only the proximinal end is preserved. The head is transversely extended and occupies most of the trochlea of the humerus, thus allowing no movement of supination. The *carpus* is creodont in character. The scaphoid is very low and flat; its proximinal surface is rounded and shows a small inner tuberosity; distallly there are three articular faces; the shape of the bone is very much as in *Mesonyx*. The lunar is very small, it is not co-ossified with the scaphoid, which it but slightly exceeds in vertical diameter; distally it shows a small facet for the magnum and a larger one for the unciform. The pisiform is short and stout. The only other carpal bone present in the specimen is the unciform which is very peculiar. The proximal surface shows a strongly convex facet for the lunar, and the radial side of the cuneiform facet is also strongly convex, while its ulnar side is concave; the distal surface is concave from side to side so that the outer edge of the bone is very thin. In the absence of the magnum it cannot be decided whether a separate central was present.

Metacarpal I is short and rather stout, the others very slender. The manus was evidently plantigrade and pentadactyl. Though proportionally very much weaker the general character of the metacarpals and phalanges is quite like that of the *Viverridæ*, the metacarpals interlocking to about the same extent, no. II touching the magnum and no. III the unciform, but not by extended surfaces. The ungual phalanges are compressed and sharp and shaped much as in *Cynogale.*

The *ilium* is short and little expanded; the outer surface is convex and of the ordinary creodont character, and the acetabulum is shallow. Of the *femur* only a small fragment of the upper portion is preserved, which shows, however, a very large second and small but perfectly distinct third trochanter; the shaft is slender and compressed. The *tibia* is long and slender, and shows a slight double curvature above forwards and below backwards; the shaft is broad and trihedral at the proximal end with prominent cnemial crest, distally it becomes subcylindrical; the distal end is not greatly expanded; a very low ridge divides the astragalar facets and makes an inconspicuous tongue; the internal malleolus is very large and has what seems to be an articular face at its distal end. The *tarsus* is at first sight much like that of the *Viverridæ*, but presents some important differences. Professor Cope states that the astragalus has "two entire trochlear faces, the wider external and directed intero-superiorly, the inner presenting supero-interiorly. They are separated by an obtuse longitudinal angle, and are little or not at all concave transversely." The species to which this astragalus belongs is not stated, but the astragalus of *D. altidens* is very different from that described by Professor Cope. It possesses a distinct trochlea, of which the external portion is the larger; the neck is long and directed obliquely inwards, and on its inner side is an excavation, apparently for the malleolus of the tibia, a very characteristic creodont feature; the head is rounded and narrow, articulating only with the navicular and not coming in contact with the cuboid. The calcaneum is short and stout, with very small sustentaculum, an expansion near the distal end and a concave cuboidal facet. The cuboid is shaped much as in *Cynogale* but without the distinct excavation for the navicular; the proximal facet is convex and the distal concave. The navicular is short with deeply concave proximal face into which the convex head of the astragalus fits; the distal surface shows three well-marked facets for the cuneiforms, and from the shape and position of the inner facet, it is plain that a hallux was present. Only the external cuneiform is preserved in the specimen; it is high and narrow, extending somewhat below the level of the cuboid; it is obvious from the facets on the inner surface that the middle cuneiform was shorter and that metatarsal II abutted against the external cuneiform.

Genus MIACIS.

IV. Miacis bathygnathus, sp. nov.

This species from the Bridger basin of Wyoming, differs from those hitherto known chiefly in its greater size. It belongs with the other Bridger species to the division of the genus in which the last lower molar has a single root although on one side of the jaw a very imperfect division of the alveolus is visible. The species may be thus defined: Length of lower molar series, m. .050, of premolar series, .027, of true molars, .023; depth of ramus below second molar, .020; no diastemata in lower dentition; mental foramina below second and third premolars; chin abruptly rounded.

The specimen upon which this species is founded consists of the left mandibular ramus in which all the alveoli are preserved, part of the right ramus retaining the first and second molars, a dorsal vertebra, portions of ulna, radius, tibia, fibula, and several metapodials and phalanges.

The inferior dentition of the genus is well known, and the only features of interest in this specimen are the absence of diastemata and the incisor formula, which can now be given. The closed dental series is repeated in the *Uintacyon* (*Miacis*) *edax* of Leidy, but the type specimen of this species shows eight teeth in the molar series. Professor Cope regards the additional tooth as abnormal, but this may not be a correct view. An analogous case is found in *Megalotis* among recent dogs. The symphysis in *Miacis bathygnathus* is narrow and the incisors closely crowded together; as Dr. Schlosser[1] has conjectured, they are three in number and are small and have very compressed fangs. As in several other genera, the first and third of the series arise at the same level while the median one is forced out and upwards. In view of the very small space occupied by these teeth, it may well prove to be the case that other creodonts which have been supposed to have a reduced number of incisors, in reality possess the full number.

The masseteric fossa is deep, with very prominent anterior edge; the condyle is heavy and beneath it on the inner side the ramus is very concave, almost like an incipient inflection; the angle ends in a short slender hook; the horizontal ramus is stout, deep and rather short, and the chin abruptly rounded; the canine is directed upwards and not obliquely forwards as in *Uintacyon edax*.

The dorsal vertebra, which is from the anterior part of the region, has a small, slightly opisthocœlous centrum; the transverse processes are short and stout; the prezygapophyses unusually large and quite strongly convex in the anterio-posterior direction, the postzygapophyses of corresponding size and concave in the same direction, the spine is trihedral, long, stout and directed strongly backwards. This vertebra resembles quite closely the third dorsal in the dog, but with proportionately stouter spine.

The fragment of *ulna*, comprising a portion of the shaft and the lower half of the sigmoid notch exactly resembles the corresponding part in *Didymictis*. The lower part

[1] Morph. Jahrb. Bd. xii., p. 293.

of the *radius* shows a broad, flattened and curved shaft with expanded and thickened distal end; the articular face gives but very faint indication of division into scaphoid and lunar facets. The character of this radius is decidedly more feline than canine. The first *metacarpal* is short and stout with a convex head for the trapezium; it is proportionately longer, heavier and with a better developed trochlea than in the dog. The fourth metacarpal is very slender; its surfaces for the adjoining metacarpals and for the unciform are almost exactly as in the dog. Professor Cope states that a specimen of *Miacis* in the Princeton museum shows the separate scaphoid and lunar bones, but this I think must be a mistake, as no such specimen is known to me. However, it is altogether probable that these bones are separate in *Miacis*, for I find them to be so in the closely allied genus *Limnocyon*, which Professor Marsh has very kindly enabled me to examine.

The proximal end of the *femur* exhibits a small head, a moderate great trochanter, a large second and very distinct third trochanter; the distal end shows nothing worthy of special mention. The *tibia* is shaped much like that of *Didymictis*, but has an almost flat astragalar face, with no tongue; this corresponds with Professor Cope's description of the astragalus. The internal malleolus is large and may have had a distal articular facet. The shaft of the *fibula* is slender, but the distal end is very heavy and forms a massive external malleolus with a large facet for the astralagus. A *phalanx* of the second row is rather long and compressed and resembles the corresponding bone in *Mustela*. The pes was obviously plantigrade and probably pentadactyl.

The systematic position of the *Miacidæ* has been much disputed. They differ essentially from all other creodonts in having but one sectorial in each jaw and these homologous with the sectorials of the Carnivora. On this account Dr. Schlosser[1] proposes to remove the *Miacidæ* to the Carnivora, and this view has much in its favor. Still important objections exist, particularly in the case of *Didymictis*. (1) The scaphoid and lunar are not co-ossified, and perhaps a central is present; (2) the femur has a well-marked third trochanter; (3) the astragalus possesses the typical creodont character of a pit for the malleolar process of the tibia; (4) the specialization of the lumbar zygapophyses is such as is found in no carnivore. To my mind these characters outweigh those derived from the dentition.

In the case of *Miacis* the material is not yet sufficient to enable us to decide its position. The presence of the full number of lower incisors is, as Dr. Schlosser points out, shared by such forms as *Stypolophus*, *Hyænodon*, and probably many other genera. The dentition is certainly very closely like that of the true Carnivora, but the structure of the feet would seem to be that of the creodonts.

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[1] Loc. cit.

MEASUREMENTS.

	M.
Length of ramus mandibuli	.098
Length of symphysis	.028
Breadth of incisor alveoli	.006
Canine, longitudinal diameter	.009
" transverse "	.006
Premolar 1, length (alveolus)	.004
" 2, " "	.006
" 3, " "	.006
" 4, " "	.009
Molar 1, length	.011
" 2, "	.008
" 3, " (alveolus)	.004

Genus PROTOPSALIS.

V. Protopsalis tigrinus (?), Cope.

This very interesting and little known genus is placed by Professor Cope between *Oxyæna* and *Pterodon*, a determination which is in accordance with the known facts of its structure. It differs from the latter genus in the fact that at least one of the lower molars has an internal cusp, and from the former in the absence of such a cusp from the last lower molar. *Protopsalis* has hitherto been found only in the Wind River beds, but in 1885 the Princeton party obtained a large creodont in the Bridger basin, which should probably be referred to here. The bones indicate a large animal of great muscular development. A fragment of the *humerus* shows a heavy shaft with a very prominent deltoid ridge extending nearly its entire length; the supinator ridge is likewise very conspicuous and a large epicondylar foramen is present. The *radius* has a transversely extended head, divided into two nearly equal concave facets, which must have covered the entire humeral trochlea; the shaft is heavy and flattened and shows prominent ridges for muscular attachments. Of the *femur* the articular surfaces are wanting, but so far as it is preserved, it agrees almost precisely with Professor Cope's figure; it is a long and heavy bone of transversely oval section. The fragments preserved indicate that the hind limb was considerably longer than the fore-limb. The *navicular* is small with a deeply concave facet for the head of the astragalus. The *cuboid* resembles that of *Oxyæna* in having a large oblique facet for the calcaneum and at an acute angle with this another for the astragalus. *Metatarsal* III shows that the foot was lighter and weaker than Professor Cope has supposed. The *phalanges* are stout and depressed, and an ungual is thick and rounded, somewhat like that of a dog. Unfortunately the distal end is broken off so that the presence of a cleft cannot be determined. A caudal vertebra indicates a long and strong tail.

If this specimen actually belongs to *Protopsalis*, there can be no doubt of the correctness of placing this genus among the *Oxyænidæ*; its relations to *Pterodon* will be considered in another place.

Genus HYÆNODON.

Four well marked species of *Hyænodon* occur in the White River beds of North America; of these *H. horridus* and *H. crucians* Leidy are accurately characterized. *H. cruentus*, however, has hitherto been imperfectly known and in his last publication Dr. Leidy inclines to the view that it is only a smaller variety of *H. horridus*.[1] A very fine skull in the Princeton museum shows that the two are, nevertheless, distinct. Aside from the difference of size the face is more depressed than in *H. horridus*, the last lower molar lacks the external buttress on the anterior lobe, and the posterior lobe of the last upper molar is externally concave and strongly curved outwards, as in *H. crucians*. The fourth species, for which I propose the name *H. leptocephalus*, is new. It is founded upon two excellent skulls belonging to the Museum of Comparative Zoology, and for an opportunity to study these very interesting specimens I am indebted to the kindness of Professor Agassiz.

This species is somewhat larger than *H. crucians*, which it resembles in dental characters and in having the cranial constriction in advance of the fronto-parietal suture. On the other hand the cranium is narrower and less rounded, and the posterior nasal canal much more prolonged, being enclosed by the whole length of the palatines and the pterygoid plates of the alisphenoids. The American species may be tabulated as follows:

I. Posterior nares opening between posterior part of palatines; pterygoid plates of alisphenoids not in contact below.
- A. Cranial constriction in advance of fronto-parietal suture, *H. crucians*
- B. Cranial constriction at fronto-parietal suture.
  - a. Face very deep; an external buttress on anterior lobe of last lower molar, *H. horridus*
  - b. Face shallower; buttress absent, *H. cruentus*

II. Palatines in contact throughout; pterygoid plates of alisphenoids meeting below, *H. leptocephalus*

The structure of the skull of *Hyænodon* has not been completely described as yet, and an attempt to do so may be of some value, even though repeating some points already determined by Dr. Leidy. In what follows *H. cruentus* is taken as a standard, reference being made to other species only when they depart from it in some particular.

The basi-occipital is short, broad, very thin and slightly convex from side to side. The limits of the other occipital bones cannot be very clearly made out, but as a whole the occiput is low and broad, somewhat like that of the opossum; the con-

[1] Ext. Mam. Faun. Dak. and Neb., p. 48.

dyles are small and quite strongly divergent; the paroccipital processes are short and closely applied to the mastoid processes. The mastoid portion of the periotic is exposed on the occiput and is about as broad as in the dog; the process is almost obsolete and is hardly at all in advance of the condyles. The region of the cranium behind the post-glenoids is exceedingly short compared with the same part in the Carnivora; the same is true of some other creodonts (e. g. *Mesonyx*) as well as of the carnivorous marsupials and the insectivores.

The basi-sphenoid is very long; posteriorly it is broad but narrows rapidly forwards; the alisphenoids are large and form considerable part of the side walls of the cranium; near the anterior edge is a strong overhanging ridge which runs obliquely forwards and upwards, and is continued on the frontal to the post-orbital process; the pterygoid plates are large and in all the species closely approximated; in *H. leptocephalus* they are actually united suturally, thus concealing the pterygoids and bringing the posterior nares very far back. The parietals are long but not very broad bones and do not extend very far down on the sides of the cranium; this extension is least in *H. horridus*, somewhat greater in *H. cruentus* and still more so in *H. crucians* and *H. leptocephalus*. In front of the squamosal the parietal sends down a process to meet the alisphenoid; the sagittal crest is not strongly developed except posteriorly. The squamosals are large, extending well up on the side of the cranium and back to the crest of the inion; they vary in size in the different species, of course inversely as the extension of the parietals, as given above; the zygomatic process is heavy and directed outwards and then curves forwards; the glenoid cavity is broad and concave in both directions; the post-glenoid process is shaped much as in the dogs, but is continued as a low ridge the entire width of the cavity; this ridge is least marked in *H. leptocephalus*; no preglenoid ridge is present.

The pre-sphenoid is narrow and but little exposed, as the vomer conceals it. The limits of the orbito-sphenoids are not easy to make out, but they are obviously very small. The frontals, on the other hand, are exceedingly large. In *H. cruentus* and *H. horridus* the cranial constriction occurs at the fronto-parietal suture, in advance of this the frontals expand rapidly and inclose large frontal sinuses; in the smaller species the constriction is just behind the orbit and the sinuses smaller. Prominent post-orbital processes are present, and as in *Thylacynus*, the nasal processes extend much in advance of the orbits.

The mes-ethmoid is exceedingly large, even more so than in the carnivorous marsupials; its size is most marked in the vertical direction, owing to the great height of the nasal chamber. The vomer is long and high. The ethmo-turbinals are well developed and complexly folded, but none of the specimens I have examined enable me to state the condition of the maxillo-turbinals. The nasals are long, broad and arched from side to side; posteriorly they are wedged in between the frontals and reach their greatest breadth at the fronto-maxillary suture; the free ends are emarginated and the internal processes extend beyond the edges of the nares. The different species vary chiefly in the length of the portion enclosed between the frontals; this is greatest in *H. horridus* and least in *H. leptocephalus*, where also the expansion at the fronto-maxillary suture is least marked.

The premaxillaries are shaped very much as in the dogs but are somewhat smaller, and have short nasal processes; the palatine plates are much reduced. The maxillaries are of great size; the two molar series diverge rapidly, so that the distance between the last molars is three times that between the first premolars; the alveolus projects far back and the palate is deeply notched on each side internally; the palatine processes of the maxillaries are slightly concave from side to side, and are nowhere very broad.

The peculiar structure of the palate in *Hyœnodon* has long been known. In *H. horridus* and *H. crucians* the hinder ends of the palatines are separated by a narrow fissure which gradually broadens, thus forming the narial opening. I have seen no specimen of *H. cruentus* in which the relations of those parts can be certainly made out, but from the structure of the portions preserved it is very probable that their condition is the same as in the species just described. In *H. leptocephalus*, as already mentioned, the posterior nares are brought very far back by the meeting of the alisphenoids and probably had no inferior opening at all.

As in *Thylacynus* and many Insectivora the lachrymal has a considerable extension on the face. The malar is rather slender, it is applied to the alveolar ridge rather close to the line of molars, but it does not form any portion of the anterior edge of the orbit which is occupied by the lachrymal; the malar arches outward from the maxillary, little if at all upwards; there is no post-orbital process.

The mandible consists of a long slender horizontal ramus which gradually deepens posteriorly and forms a very long symphysis with its fellow. The differences exhibited by the various species are chiefly in the ascending ramus. In *H. horridus* the coronoid is high and pointed, its hinder edge very oblique and its summit much in advance of the condyle; in *H. crucians* and *leptocephalus* the coronoid is much broader, its posterior edge is nearly vertical and almost overhangs the condyle; the masseteric fossa also differs in shape; in *H. crucians* it is rather shallow and most extended vertically, in the other species it is very deep and extends far forwards. *H. horridus* shows two mental foramina, the other species three; their position does not seem to be constant. In all the species the condyle is placed low, below the line of the teeth, and in all there seems to be an angular hook, though I have made it out with certainty only in *H. cruentus*.

Foramina. M. Filhol[1] has described the foramina of *H. brachyrhyncus* and states that the condylar foramen, foramen lacerum posterius and carotid canal are all

[1] Filhol, Mém. sur quelques Mam. Foss., 1884, p. 19.

separate and that an alisphenoid canal is present. The American species present some important deviations from this arrangement. The condylar foramen is situated nearer the medium line than in M. Filhol's specimen and in *H. cruentus* there is an exceedingly minute foramen immediately in advance of it, which does not seem to occur in *H. horridus*. The foramen lacerum posterius is placed as in the cynoid series close behind the tympanic bulla, instead of being isolated as in *H. brachyrhynchus*, and the carotid canal seems to be found with it, though this I cannot definitely state. The foramen lacerium medium is situated as in the dogs and the same may be said of the stylo-mastoid foramen. The foramen ovale is placed opposite the glenoid cavity and owing to the breadth of the basisphenoid at this point is widely separated from its fellow of the opposite side. I have examined many skulls of the four American species, but none of them show any alisphenoid canal, a very important deviation from the species described by M. Filhol. In some American specimens a shallow pit occurs where the posterior opening of the canal would be, and this may possibly represent the remnant of such a canal. An unusually wide interval occurs between the foramen ovale and the foramen rotundum, which is close to the sphenoidal fissure and this to the optic foramen. These three foramina are enclosed in a common groove formed by the ridge already mentioned which runs downwards and backwards along the frontal, orbito- and ali-sphenoids. The posterior palatine foramina are placed opposite the interval between pm. 4 and m. 1; the anterior are narrow ovals and reach close to the incisive alveolus. The infra-orbital foramen is placed far forward immediately over pm. 3; the lachrymal foramen is single and opens within the orbit. As Professor Cope has shown, three venous foramina connected with the lateral sinus are present in *Hyænodon*, the postglenoid, postparietal and mastoid.

The Brain. Gervais[1] has figured and described a cranial cast which he attributes to *H. leptorhynchus*. "J'ai pu observer une partie d'un moule cérébral naturel de l'*Hyænodon leptorhynchus* et y constater la presénce de circonvolutions bien plus semblables à celles des carnivores des deux groupes des Félis et des Hyènes qu' à celles du Thylacyne. C'est le moule de la moitié postérieure d'un hémisphère cérébral de ce carnivore extrait de la partie correspondante de la boîte crânienne sur une pièce recueillie dans la Limagne d'Auvergne par l'abbé Croizet.

"On y voit la moitié postérieure de la circonvolution de la faux ou quatrième circonvolution de la face convexe qui s' élargit en avant pour recevoir le sillon crucial, mais sans que ce sillon ait été conservé, et la troisième circonvolution ou circonvolution intermédiaire interne bien nettement séparée de la précédente ainsi que de ce qui reste en arrière de la seconde circonvolution ou circonvolution intermediare externe. Celle-ci parait se fondre, comme chez les Félis et les Hyènes, avec la branche montante postérieure de la circonvolution sylvienne dont la branche antérieure n'est pas visible.

[1] Gervais, Nouv. Arch. d. Mus. 1re Sr. t. VI, p. 127, pl. VI, fig. 5.

La scissure semble plus élargie que d'habitude et les plis offrent moins d'ondulations que sur les cerveaux de même taille appartenant aux espèces actuelles; mais le caractère fondamental des cerveaux du quatrième groupe de Leuret subsiste, et c'est près des Félis et des Hyènes que l'on doit placer le genre Hyénodon."

Gervais does not state whether this fragmentary cranium was associated with teeth, which would render its reference to *Hyænodon* unquestionable, and its shape does not agree very well with that of the crania figured by De Blainville and Filhol. At all events this cranial cast is very different from the characters exhibited by the American species, of which I have examined two, *H. crucians* and *H. horridus*, the former in the Academy's collection and the latter in the Princeton museum. One is forced to conclude either that the brain figured by Gervais belongs to some other genus or that the American species differ from the European much more widely than has been supposed.

The cranial cast of *H. crucians* (partially figured by Dr. Leidy in his Ext. Mam. Faun. of Dak. and Neb., Pl. II, fig. 2) is essentially unlike Gervais's specimen. The hemispheres are long and narrow, with straight and not very strongly marked convolutions; no indication of the crucial sulcus is to be seen; the limits of the frontal lobes are not very clear, but they must have been very small; the temporal lobes are large and the sylvian fissure widely open; the olfactory lobes are large and completely exposed. It is rather difficult to make out the exact number of longitudinal convolutions; probably, however, there are three: the sylvian gyrus has a broad posterior branch, the anterior being absent. The intermediate and internal gyri are straight and show no tendency to undulate or divide, nor are connecting gyri to be seen. This brain is not in the least like that of the cats and hyenas, but is more like that of *Stypolophus* (*Cynohyænodon*) as figured by M. Filhol.

The cranial cast of *H. horridus*, compared with that of *H. crucians*, is an excellent example of Gervais's principle of an increase in cerebral complexity accompanying an increase in the stature of the species. This brain is long and narrow, broadest posteriorly and tapering regularly forwards; the olfactory lobes are very large and not overlapped by the hemispheres, which also leave the cerebellum entirely uncovered; the temporal lobes are very large and the frontal exceedingly small. Four longitudinal convolutions seem to be present; the sylvian gyrus has only the hinder branch developed, which bends around posteriorly and joins the external median gyrus; the latter is straight, runs obliquely forward and inward, and at its anterior end joins the internal gyrus. The internal median gyrus is very short and joins the internal both behind and before; perhaps it would be better to consider this as simply a partial division of the internal one. In addition to these a small curved gyrus occurs on the frontal lobe. The great difference between this brain and that of *H. crucians* consists in the connection between the convolutions. There is no indication of a crucial sulcus, and no outward curvature of the median gyrus. Indeed, all the convolutions are straight and show no undulations, except the small curved frontal gyrus. The cerebellum is large, being broader than the hemispheres; the vermis is rather narrow and not very prominent, but the lateral portions are very large and obscurely convoluted. (See Pl. VII, Fig. 4).

The brain of *H. horridus* is strikingly small when compared with the size of the skull; it is proportionally but slightly longer than the brain of *Thylacynus*, and not quite so broad; the latter also shows considerable similarity in the pattern of the convolutions, though these are very obscure in a cranial cast. (See Gervais Nouv. Arch. d. Mus., t. v., Pl. XIV, Fig. 5).

Thus Gervais's specimen is seen to differ from the American species in shape, in the much narrower cerebellum, and in the character of the convolutions.

Skeleton.—A most important and valuable specimen of *H. horridus*, belonging to the Museum of Comparative Zoölogy, has been very kindly sent to me by Professor Agassiz. This specimen, I think, will decide the disputed question as to the systematic position of this curious genus.

The *atlas* has rather small transverse processes, which do not seem to be pierced by the vertebral canal; the superior and inferior arches are slender. The *axis* is in some respects like that of *Mesonyx*; the centrum is broad and much depressed, with a strong keel; the atlanteal faces are narrow, transversely directed and not emarginated by the neural canal, which is small; the transverse processes are long, stout and perforated at the base; the spine is high and thin, and posteriorly forms a stout rod which projects to the 4th vertebra; this rod is horizontal instead of oblique, as in *Mesonyx*. A somewhat similar arrangement is seen in *Lutra*. This specimen shows clearly that the axis doubtfully attributed to *Hyænodon* by M. Gaudry (Ench. d. Monde Anim., fig. 9) must belong to some other genus. No resemblance to the opossum's axis is to be found in the specimen before us. The other cervical vertebræ are rather long, with opisthocœlous centra, and large, very oblique zygapophyses; the spine of the 3rd is a low ridge, that of the 7th long and stout; the others are too much broken for determination.

The *dorsal* vertebræ, of which the anterior seven are represented, have rather short, heavy and depressed centra, and very strong neural spines; but, as none of the latter are complete, their length cannot be stated; all the spines incline strongly backwards. The first dorsal is remarkable for the large size of the transverse process, and its strongly concave facet for the tubercle of the rib; the second has a similar but somewhat smaller process, and in the other vertebræ the process becomes of the ordinary size, though conspicuous in all. In proportion to the size of the skull, these vertebræ are larger and have heavier processes than those of *Mesonyx*, indicating a more powerful animal.

Of the *lumbar* series five are preserved; they have very large centra which are broad, depressed, slightly opisthocœlous and, except the last, provided with keels; the transverse processes are long, but not very broad; they are curved sharply forward and terminate in a point; the spines are of moderate height, but have great antero-posterior extent and incline strongly forward, that of the last vertebra is nearly vertical. *Hyænodon* shows in a very marked degree the creodont peculiarity of the lumbar zygapophyses; the prezygapophyses are exceedingly concave and curve far over; into these the convex, nearly cylindrical postzygapophyses, fit. The metapophyses are small and in the last three vertebræ rudimentary; small anapophyses are present.

The *sacrum* consists of three vertebræ; the first has a broad and depressed centrum, with very large pleurapophyses and long oblique transverse processes; the prezygapophyses are shaped as in the lumbar region, but are much lower; the spine is low and not ankylosed with that of the succeeding vertebra. The second sacral is of about the same length as the first, but much narrower; only the anterior corner of the pleurapophysis is in contact with the ilium which is carried almost entirely by the first vertebra; the spine is low. The third sacral is the smallest of all. No caudal vertebræ are preserved, but *Hyænodon* probably possessed a long tail.

Ribs.—The anterior ribs are very broad and flat; this flattening is marked as far as the sixth; behind that the ribs become more rounded. The first rib is especially broad and has an exceedingly large and convex tubercle; the second is similar but has a smaller tubercle; in the others the tubercle is less conspicuous and somewhat saddle-shaped.

The fore-limb is proportionally longer and heavier than in *Mesonyx*, but strikingly weak when compared with the modern Carnivora. The *humerus* (which is somewhat crushed and has lost its proximal end) has a long and rather slender shaft, with a prominent deltoid ridge; the supinator ridge is low; an epicondylar foramen is present, as is also the supratrochlear; the anconeal fossa is broad and very deep; the trochlea has a prominent ridge and the internal edge is prolonged downwards; the condyles are not very prominent. This humerus agrees quite well with that of *H.* (*Taxotherium*) *parisiensis*, as figured by De Blainville (Subursus, pl. xii), but differs in the presence of the supratrochlear foramen and the greater prominence of the intertrochlear ridge.

The *ulna* is rather short and stout; the shaft, though flattened, is heavy, and is convex on the inner, deeply channelled on the outer side; the olecranon, as in the creodonts generally, is very prominent; the sigmoid notch is deep and the radial facets occupy nearly the entire anterior face of the lower end, only a small portion of this face is in contact with the humerus. De Blainville's figure differs from this specimen only in the somewhat reduced radial surface. The distal end is much compressed and ends in a rounded-convex facet for the cuneiform.

The *radius* has a broad proximal end, which occupies nearly the whole breadth of the humeral trochlea; the upper part of the shaft is broad and flattened; below it becomes rounder and much stouter; the distal end is expanded and thickened, especially on the outer or ulnar side, giving a very similar shape to that seen in the large cats.

The *carpus* is entirely creodont in character, and differs from that of any known carnivore in the presence of a central and the separation of the scaphoid and lunar. The scaphoid has a very small vertical diameter; its proximal surface shows an inner concave surface and an outer convexity; the distal facets meet at a low angle. The lunar is narrower but of greater height than the scaphoid, and the radial surface comes far down on the anterior face; it has not the regular wedge-shape seen in *Mesonyx*, but shows an infero-lateral surface for the central, a very small inferior face for the magnum and a still smaller one for the unciform. The cuneiform is a large, square bone; on the external side it gives off a strong recurved hook-like process; the ulnar and unciform facets are both concave. The pisiform is very large and is especially expanded at the free end. The trapezium is of very unusual size; it descends below the level of the trapezoid and abuts against the radial side of the second metacarpal. The trapezoid is smaller; it has little contact with the scaphoid, being almost completely separated from it by the central; its metacarpal facet is saddle-shaped. The central has a more internal position than in *Mesonyx*, being wedged in between the scaphoid and trapezoid and touching the magnum and lunar by small surfaces; it is wedge-shaped, with the edge placed anteriorly; posteriorly it thickens rapidly. The magnum is missing from the specimen, but from the relations of the surrounding parts it was obviously small. The unciform is large and has a subquadrate anterior face; nearly all the proximal surface is covered by the cuneiform, leaving a very small facet for the lunar; the surfaces for the fourth and fifth metacarpals are plainly marked; the latter is altogether distal and does not extend on the external side.

As a whole, the carpus is very low and broad. (See Pl. VII, Fig. 5).

The *metacarpals* are five in number, and, as in *Mesonyx*, show a greater degree of interlocking than in any carnivores except the cats. In order of length they are III, IV, II, V, I. No. I is quite short, but stout, especially proximally, and fits into the trapezium by a convex head. No. II is the stoutest of the series; on the radial side of the proximal end it has a facet for the trapezium; the ulnar side is somewhat excavated for No. III, and sends out a strong process, which abuts against the magnum. No. III is the longest and slenderest of all; its upper end is mutilated, but it obviously overlapped No. IV and abutted against the unciform, which shows a facet for it. No. IV is of very similar size and shape; a large, rounded head articulates with the unciform, and on its ulnar side there is an excavation for No. V. This last is short and stout; its unciform facet is convex and articulates only with the distal surface of the unciform. The proximal *phalanges* are strong and somewhat depressed; no median phalanges are preserved. The unguals are peculiar. They are short, heavy, moderately compressed and blunt; the proximal facet is deeply concave and shows beneath it a tubercle for the attachment of the tendon, which, however, forms no such process as in the cats. At its free end the phalanx is deeply cleft for nearly half its length. This claw tends to confirm the inference drawn by Gervais and others, from the structure of the palate, as to the aquatic habits of the genus, and it proves conclusively that the hind leg and foot which I formerly referred to *Hyænodon*, belongs to some very different form.

There is still much doubt as to the structure of the carpus in the European species of *Hyænodon*. Professor Cope states[1] that in a specimen of *H. requieni*, from Desbrusges, in the Jardin des Plantes, the scaphoid and lunar are coössified. On the other hand De Blainville's figure of *H. parisiensis* agrees very well with the specimen just described, and seems to show the impression of a separate lunar.

The only part of the hind-limb preserved is the *ilium*; this is rather feline in character, being but slightly expanded and showing a deep gluteal surface.

This survey of the osteology of *Hyænodon* brings out some important and, apparently, constant differences between the American and European species of the genus. More perfect knowledge of the French species will not improbably necessitate the division of the genus *Hyænodon* as now understood, and the revival of De Blainville's name *Taxotherium*; his figure of *T. parisiensis* shows no alisphenoid canal, agreeing with the American species; though this may, of course, be an oversight. The name *Taxotherium* would, in this case, include those species which have separate scaphoid, lunar and central bones in the carpus, no alisphenoid canal, cerebral hemispheres not broader than the cerebellum, and with straight convolutions. The name *Hyænodon* would then be limited to the species with coössified scaphoid and lunar, an alisphenoid canal, hemispheres with winding convolutions and broader than the cerebellum. It would be premature to make this division until the reference of the French specimens of carpus and brain can be cleared up.

As far as the American species are concerned, their systematic position can now hardly be a matter of doubt. M. Gaudrey's view as to the marsupial character of the genus is definitely disproved by the abundant material now at command. Some resemblances to *Thylacynus*, it is true, are apparent; but these features are also common to the Insectivora, and only the dentition can be supposed to indicate remote marsupial affinities. M. Filhol,[2] on the other hand, contends that *Hyænodon* is a true carnivore, but the teeth, the carpus and the vertebræ forbid any such reference of the American species, and even if furthur investigation should show that most of the French species have the scaphoid and lunar coössified and thus necessitate the revival of *Taxotherium*, it would be a very unnatural and arbitrary mode of classification to place two such closely allied genera in different orders. The character of the dentition is alone sufficient, it seems to me, to forbid the reference of *Hyænodon* to the Carnivora.

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[1] Tert. Vert., p. 256. [2] Loc. cit.

Mr. Wortman[1] places the genus among the Insectivora; but this I consider to be altogether untenable, as is shown by the convoluted brain, the sectorial dentition, and the structure of the vertebræ.

The origin of the *Hyænodontidæ* offers a more difficult problem. I was formerly inclined to follow Professor Cope in deriving them from the *Mesonychidæ*, but the more perfect specimens described in this paper have convinced me that this view is erroneous, as the structure of the feet prove, not to mention other characters. The evidence now available would seem to point to the *Oxyænidæ* as the family among which the ancestors of *Hyænodon* are to be sought. M. Filhol has shown the close relation which exists between *Hyænodon* and *Pterodon*; the latter is distinguished by the formula pm. $\frac{4}{3}$, m. $\frac{3}{3}$, the presence of internal cusps on the upper molars, the less extensive union of the palatines, and by the union of the foramen lacerum posterius with the carotid canal. Most of these distinctions are primitive and the only specializations which *Pterodon* shows are the coalescence of the foramina and the loss of the first lower premolar. It seems therefore reasonable to regard the two genera as descended from a common ancestor very similar to *Pterodon*. This genus is plainly allied to *Oxyæna*, indeed Cope includes them in the same family; between these two genera comes *Protopsalis*. *Oxyæna* itself cannot be the ancestral genus, on account of the reduced dentition; but probably some Oxyæna-like form, with full dental series, will prove to be the desired ancestral type.

(The measurements of *Hyænodon* are included in the same table with those of *Mesonyx*.)

The definition of the group Creodonta is by no means easy, as the order is such a large and heterogeneous one. Professor Cope informs me that the only diagnostic character which he can find is the involution of the posterior dorsal and lumbar zygapophyses. A provisional definition may be attempted as follows: Unguiculate mammals having separate scaphoid and lunar bones in the carpus; a central bone (probably) present in all; brain small, but in most cases more or less convoluted; molar teeth usually all sectorial or tuberculo-sectorial; interlocking of posterior dorsal and lumbar zygapophyses very perfect.

In conclusion I wish to express my thanks to the Academy, and to Professors Agassiz and Cope for the loan of valuable material, and to Professor Marsh for allowing the opportunity to study some of his unique specimens.

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[1] American System of Dentistry, p. 420.

EXPLANATION OF THE PLATES:

Plate V.

Mesonyx obtusidens.—Cope. Restoration of skeleton about ⅛ natural size; mostly from one individual found at Twin Buttes, Wyoming, and now in the Princeton Museum.

Plate VI.

Fig. 1. *Mesonyx obtusidens;* side view of skull, two-fifths natural size.

1*a*. Base of same skull.

Fig. 2. *Hyænodon cruentus.*—Leidy. Side of skull two-fifths natural size.

2*a*. Base of same skull.

Plate VII.

Fig. 1. *Mesonyx obtusidens;* left manus.

Fig. 2. *Mesonyx obtusidens;* left pes. In this figure the artist has omitted to indicate that the length of the metatarsals, except No. V, is conjectural. Proximal and distal ends and most of the shafts are present in the specimen for all the metatarsals, but only No. V is complete.

Fig. 3. *Mesonyx obtusidens;* phalanges of 3rd digit of manus.

Fig. 4. *Hyænodon horridus*—Leidy. Natural cranial cast.

Fig. 5. *Hyænodon horridus;* right manus from a specimen belonging to the Museum of Comparative Zoölogy, at Cambridge, Mass.

Fig. 6. *Hyænodon horridus;* phalanges of pollex of same specimen.

(Figures of Plate VII all natural size).

ON THE STRUCTURE AND CLASSIFICATION OF THE MESOZOIC MAMMALIA.

By Henry Fairfield Osborn.

In 1871, when Professor Owen completed his "Monograph upon the Fossil Mammalia of the Mesozoic Formations," there were but twenty genera of this period known to science, two of which only, *Dromatherium* and *Microlestes*, were from Triassic beds, and the remainder from the Jurassic. The genera have now been increased to over thirty-five, five of these coming from the Trias. These numbers alone cause us to modify our former ideas as to the paucity of mammalian life in the Mesozoic period. In a rapid survey of this ancient fauna, we are at first struck with the very great diversity which prevails in the form and arrangement of the teeth, consisting of six or seven wholly distinct types; and this at a zoölogical period which we have been accustomed to consider as the dawn of mammalian life. The above types, although primitive, are essentially mammalian. In one genus only, *Dromatherium*, do we find clear evidence of reptilian affinity in the dentition. Then we are surprised to discover a very close zoölogical relationship between fossil faunæ of the same age, but having a wide geographical distribution. The most striking instance of this is the parallelism between the American and British upper jurassic fauna. For, among the thirteen genera discovered by Professor Marsh in the Atlantosaurus Beds, or American Upper Jurassic, six have their counterparts in the English Middle Purbeck, and the family characters are very close as regards the remainder. The two American triassic genera, *Dromatherium* and *Microconodon*, are isolated, but the genus *Tritylodon*, from the South African Trias, has a close ally in *Triglyphus* from the Rhaetic beds near Stuttgart, as Neumayr has pointed out; it is also related to the genus *Bolodon* from the Purbeck, and probably has a lateral successor in *Polymastodon*, a highly modified form found in the American Puerco beds. The most remarkable distribution, both geographically and stratigraphically, has, however, been enjoyed by *Plagiaulax*, which extends from *Microlestes*, in the Trias of Germany and England, to *Ptilodus* in the Puerco of New Mexico, and *Neoplagiaulax* in the lower Eocene of France, probably terminating, by a side branch, in *Thylacoleo* of the Australian Quaternary. The following table shows the geological and geographical distribution of the known mesozoic genera and of their tertiary descendants:

	ENGLAND.	NORTH AMERICA.	GERMANY AND FRANCE.	AFRICA AND AUSTRALIA.
Quaternary.				Australian Bone Caves. *Thylacoleo.*
Eocene.		Lowermost Eocene, Puerco. *Polymastodon,* *Ptilodus,* *Chirox,* *Neoplagiaulax.*	Lower Eocene, Cernaysienne. *Neoplagiaulax.*	
Cretaceous.		Uppermost Cretaceous, Laramie. *Meniscoëssus,*		
Jurassic.	Upper Jurassic, Middle Purbeck Beds. *Spalacotherium,* . . *Amblotherium,* *Achyrodon,* *Phascolestes,* . . . *Athrodon,* *Stylodon,* . . . . *Peralestes,* *Peraspalax,* *Leptocladus,* *Triconodon,* . . . *Triacanthodon,* *Plagiaulax,* . . . *Bolodon,* . . . . . *Peramus,* Lower Jurassic, Stonesfield Slate. *Amphitherium,* *Amphilestes,* *Phascolotherium,* . . *Stereognathus,* *Amphitylus.*	Upper Jurassic, Atlantosaurus Beds. *Paurodon,* *Menacodon,* *Diplocynodon,* *Docodon,* *Dryolestes,* *Stylacodon,* *Priacodon.* *Asthenodon,* *Laodon,* *Triconodon,* *Enneodon,* *Ctenacodon,* *Allodon,* *Tinodon.* (*Tinodon.*)		
Triassic.	Uppermost Triassic or Rhaetic. *Microlestes.*	Uppermost Triassic or Jura Trias. *Dromatherium,* *Microconodon.*	Uppermost Triassic or Rhaetic. *Microlestes,* *Triglyphus,*	Upper Triassic, Stormberg Beds, S. Africa. *Tritylodon.*

N. B.—The genera in adjoining columns and connected by dotted lines are closely related to each other. Professor Cope now considers the *Puerco* as uppermost Cretaceous. Judging by the degrees of specialization observed in the related American and British genera, the American Upper Jurassic beds are slightly older than the Purbeck

A third fact of great interest is the presence in the Mesozoic period of types of teeth which have persisted in some cases to the Eocene, and in others even to recent times. Very careful observation shows that the dentition of these minute mammals is less archaic than it appears at first sight, and more upon the somewhat unspecialized lines characteristic of certain modern genera. An exception to this statement must be made in regard to the excessive number of teeth. In the greatly extended field of exploration we should have anticipated finding one or more types of dentition wholly distinct from those described by Professor Owen from the English Jurassic; but this has not proved to be the ease. From the very fact of their general zoological relationship, however, these newly-discovered genera from other countries are of greater interest in their bearing upon the structure and relationships of the English genera. It is not so much then the form of the teeth as the presence of an exeessive number of molars, which gives a primitive character to the jurassic fauna. In other respects it is, upon

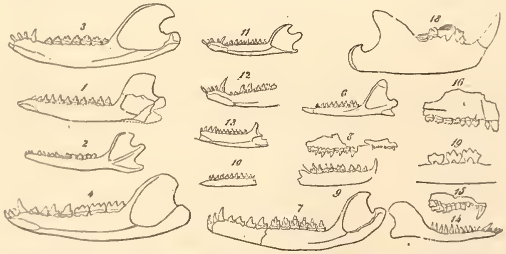

FIGURE 1. The types of the British mesozoic mammals, representing the natural size. 1. *Amphilestes*. 2. *Amphitylus*. 3. *Phascolotherium*. 4. *Triconodon mordax*. 6. *Peramus*. 7. *Spalacotherium*. 8. *Peralestes*. 9. *Peraspalax*. 10. *Leptocladus*. 11. *Amblotherium*. 12. *Phascolestes*. 13. *Achyrodon*. 14. *Stylodon*. 15. *Athrodon*. 16. *Bolodon*. 18. *Plagiaulax minor*. 19. *Stereognathus*.

the whole, surprisingly modern. The various divisions of the dental series are almost as sharply defined as in modern genera. Another eharacteristie is the diminutive size of this fauna. As shown in the accompanying series of life-size outlines of the mandibular and maxillary specimens, the genera vary from the size of the smallest Rodents to that of the smaller varieties of the Hedgehog.

Literature. Professor Owen gave in his Memoir a full list of the papers upon the Mesozoic Mammalia which had appeared previously. The most valuable among these were his own contributions upon the Stonesfield Slate genera in the "Transactions of the Geological Society, 1835", and Dr. Falconer's Memoirs upon *Plagiaulax* in the "Quarterly Journal of the Geological Society," in 1857 and 1862. Professor Owen's well known Memoir of 1871, embraced a very elaborate and able description and discussion of all the Mesozoic genera which were then known. In 1878 Professor Marsh first discovered the Amerieau jurassie mammals, and began a series of brief papers in the *American Journal of Science and Arts*, which have since appeared frequently. In 1878 Professor Cope discovered the Puerco Beds, in New Mexico, which have subsequently yielded several genera closely allied to the mesozoic forms described by him in the *American Naturalist*, in the "Proceedings of the American Philosophical Society," and in his large memoir upon the "Tertiary Vertebrata." In 1883 Dr. Lemoine published his valuable memoir upon *Neoplagiaulax*. In 1884 Professor Owen described the remarkable genus *Tritylodon*, which may prove to be the same as *Triglyphus* previously described by Professor Fraas in his work "Vor der Sündfluth," p. 215. In 1884 Professor Cope published a highly suggestive paper upon the Tertiary Marsupialia, in which he described *Meniscoëssus* from the Cretaceous, and pointed out the ordinal relations of *Tritylodon*, *Polymastodon* and *Plagiaulax*. The most recent contribution to this subject is an important article by Professor Marsh on the "American Jurassic Mammals," which appeared in April, 1887.[1] This marks a very great advance in our knowledge of the jurassic forms previously known, and adds many new genera, together with a classification of the American and some of the British forms.[2]

Preparation of the present memoir.—Through the kindness of the members of the Geological Department of the British Museum, I was recently enabled to study the fine collection of mesozoic mammals preserved there, which formed the principal material for Professor Owen's monograph. My original intention was simply to review the types as described by him, but the discovery of new facts followed so rapidly that the plan of a systematic revision of these forms gradually resulted. While naturally confirming the greater part of Professor Owen's observations, I was led to

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[1] The MSS. for the present memoir was nearly prepared when I received this article. The principal service it afforded me, in connection with the British types, was in correcting my views of the supposed family relationship of *Stylodon* and *Athrodon*; in showing the full pattern of the *Stylodon* type of molar, and in the discovery of the maxillary dentition of *Plagiaulax*, which widened the separation of this genus from *Bolodon*. The transitional dentition of the genera *Menacodon* and *Tinodon* also first suggested to me the relationship of *Spalacotherium* to *Phascolotherium*. The importance of this contribution arises not merely from the variety of new forms described, but from the fact that the author has, in many cases, studied both faces of his specimens by freeing them from the matrix entirely, whereas most of the British types are still partly imbedded in the matrix.

[2] *Partial List of Memoirs and Shorter Articles:*

Professor Richard Owen.

1. Monograph of the Fossil Mammalia of the Mesozoic Formations. Palaeontographical Society, London, 1871.
2. On the Skull and Dentition of a Triassic Mammal (*Tritylodon longaevus*, Owen) from South Africa. "Quarterly Journal of the Geological Society," 1884.

Dr. Victor Lemoine.

3. Etude sur le Neoplagiaulax de la Faune Éocène inférieur des Environs de Reims. Extrait du "Bulletin de le Société Géologique de France." Fevrier, 1883.

Professor E. D. Cope.

4. The Tertiary Marsupialia. "American Naturalist," 1884, p. 687.

Professor O. C. Marsh.

5. The American Jurassic Mammals. "American Journal of Science and Arts." April, 1887.
6. On the structure and classification of the Mesozoic Mammalia. (Abstract of this memoir). Proc. Phila. Acad., June, 1887,

differ from him in some important respects, profiting in several cases by the new material which has been added to the collection since the publication of his memoir. Every facility for this study was extended to me by my friends, Dr. Woodward, Mr. Etheridge, Mr. Davies and Mr. Smith Woodward, to whom I wish to express my sincere appreciation. I have also enjoyed much assistance in other collections. Dr. Lemoine, of Rheims, kindly allowed me to examine, with the rest of his materials, his very interesting series of the Eocene *Plagiaulax.* Professor Cope generously placed his Puerco collection in my hands for study and comparison. Professor Marsh, having a memoir upon the Mesozoic Mammalia in preparation, has kindly permitted me to make a careful examination of the type specimens of his various genera, which has been of great assistance. The American Triassic genera have also been studied from the original specimens in the Williams College and Philadelphia Academy collections. I did not have an opportunity of examining the types of *Amphitherium*, *Amphitylus* and *Amphilestes*, and am much indebted to Mr. Lydekker for the assistance he has extended in connection with the study of these genera. Influenced by these opportunities the purpose of the present memoir has gradually shaped itself as follows:

1. To present as clearly as the available material allows, the characteristic features of each of the British mesozoic genera, without especial regard to specific characters.

2. To present the principles upon which the mesozoic mammals, in general, may be classified into larger and smaller zoölogical divisions and families, including a complete generic synopsis. Also, to show their relationships to modern orders of mammals.

3. To discuss the dentition of these genera in its bearing upon the origin and succession of mammalian tooth forms.

I. THE BRITISH MESOZOIC MAMMALIA.

The following description of the British genera is based upon study of the original specimens in the case of all except the lower Purbeck genera above mentioned; also *Stereognathus* and some of the molars of the Rhaetic *Microlestes* and *Hypsiprymnopsis.* With the aid of Mr. Lydekker, I have here largely relied upon Professor Owen's drawings and descriptions, and thus have been able to place only one of these genera in the series of typical figures given upon plates VIII and IX. The notes upon these genera are, therefore, somewhat less complete. In the course of studying the type specimens which, as seen in the accompanying figure (1), are often extremely minute and difficult to grasp, I have learned to attach great importance to minor characters such, for example, as the basal cusps of the premolars, which prove to have a very important bearing upon the problems of affinities and classification. These cusps present various degrees of development and a variety of shapes, which in every case have fixed relations to the pattern of the molars, canines, incisors and to the shape of the mandible; in other words to the kind of diet. In order to bring out these minor characters clearly, the drawings have been finished with the utmost care and made upon a very large scale.[1] A second principle adopted in the drawings is that of *composition*, upon a system which is fully explained in connection with the text of the plates. While open to some objections this has the effect of bringing all the known characters of a species which can be legitimately placed together, before the eye at the same time. In Professor Owen's Memoirs, the majority of the specimens thus placed together are figured separately. The numbers correspond with those affixed to the specimens in the British Museum collection.

AMPHITHERIUM.

Since the publication of Professor Owen's memoir, a portion of a small jaw from the Stonesfield Slate has been added to the British Museum collection and referred to *Amphitherium* (No. 36,822). The teeth preserved are the last premolar and five molars, in all of which the crowns are perfect. A close examination of these crowns, in comparison with the figures of *A. Prevostii* (Mes. Mamm., Pl. I, fig. 23), and of *A. Broderipii* (Pl. I, fig. 25), at first led me to believe that this specimen was wholly distinct from *Amphitherium*, but subsequently these molars were found to correspond closely to the somewhat mutilated molar crowns of the type specimen of *A. Prevostii*, as figured in Pl. I, figs. 21 and 22. Unfortunately I was unable to compare the original types, but from a study of all the drawings and descriptions available, this correspondence has been confirmed, and the conclusion reached that among the specimens heretofore referred to *Amphitherium*, we have the types of three distinct genera. The *A. Broderipii* has, in fact, already been separated with some qualification, by Professor Owen,[2] under the name *Amphilestes*; the third genus remains to be distinguished.

Let us begin with the type specimen of *Amphitherium*,[3] the first to be discovered and described. All the numerous figures of this specimen which have been published[4] agree as regards the pattern of the molar crowns. Observe especially m_4, m_5, and m_6. "In the fifth molar the middle external cusp is nearly entire to its sharp apex; part of the anterior cusp and the base of the internal posterior cusp are preserved." In this description Professor Owen indirectly suggests that the summit of the posterior cusp has been broken away. If we adopt this suggestion we must suppose that the

[1] Palaeontology has suffered much from the mistaken custom of making figures large or small in direct proportion to the size of the object illustrated. A quarto plate will often be devoted to some very large object in which perhaps the anatomical details are few and simple, while a row of small teeth, full of important diagnostic characters, is crowded into such a small scale that it is impossible to make out the details.

[2] Mes. Mamm., p. 16.

[3] De Blainville, Comptes Rendus. Aug. 20th, 1838.

[4] Prevost. Ann. des Sc. Nat., April, 1825, (Pl. 18, fig. 2). *Owen, Geol. Transactions*, Ser. 2, Vol. VI., 1839. Also, Brit. Foss. Mamm., (fig. 16); and Mes. Mamm., (figs. 21 and 22).

third cusps of all the molars are also broken, which is very improbable. The fact is, these crowns of the molars consist of elevated anterior and median cusps, followed by a *low posterior heel*, and with an internal cingulum rising into the low cusp on the inner face of the median cusp. When these mutilated crowns are compared, one by one, with the perfect crowns of the newly-acquired jaw (No. 36,822) there can be no doubt that they belong to the same pattern. If this be the case, the latter specimen is of great interest, as it enables us for the first time to fully characterize the molar dentition of *Amphitherium*.

These teeth deserve a somewhat detailed description, (fig. 2). They are seen upon the outer surface, which is devoid of a cingulum. The premolar, which is probably pm_4, closely resembles pm_4, of *A. Prevostii* (fig. 22, Mes. Mamm.). The crown is bifanged and slightly recurved, with a low posterior heel, and a cusp upon the anterior slope, which probably represents part of the internal cingulum. The molars, in general, dif-

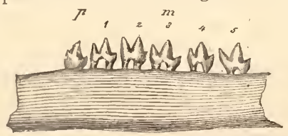

FIGURE 2.—A portion of the left mandible of the *Amphitherium Prevostii*, seen upon the outer surface, approximately five times the natural size, from a specimen in the British Museum collection.

fer from those of the *A. Prevostii* (fig. 23, Mes. Mamm.), first, in the repression of the third, or posterior cusp, which is replaced by a low, sloping heel; second, in the elevation of the anterior cusp, which rises nearly to the level of the middle cusp; they differ from those of *A. Broderipii*, both in the absence of the posterior cusp and of all trace of a cingulum upon the anterior and posterior slopes of the crown. The molars, as a series, are sub-equal, but the size of the anterior cusp and the width of the posterior heel varies somewhat. These teeth, at first sight, approach those of *Amblotherium* (Pl. IX, fig. 11), and *Phascolestes* (fig. 12), somewhat more closely than those of *Amphilestes* or *Amphitylus*. They are, however, widely distinguished from the *Amblotherium* molars by the prominence of the anterior lobe, the stout, erect and conical character of the middle lobe, the narrowness of the heel, the strong internal cingulum, and by the sub-equal size of the series as a whole. The same features distinguish them from the molars of *Phascolestes*, a genus which stands near *Amblotherium*, but is distinguished by external cusps.[1] The separation of this genus from the two following leaves the dental formula of *Amphitherium* uncertain.

AMPHITYLUS.

AMPHITYLUS OWENI, gen. et spec. nov.[2]

The accompanying cut shows how widely the molars just described differ from those of the third specimen referred to *Amphitherium* by Professor Owen, *viz*, the *A.*

[1] It is now probable that *Phascolestes* belongs to the *Stylodon* family.

[2] See also abstract, Proc. Phila. Acad., June, 1887.

Prevostii of the Buckland Collection (Mes. Mamm., fig. 23); also how the latter differ from those of *Amphilestes*. It is clear that the two fossils, last named, resemble each other much more closely than they do *Amphitherium*, and in the discrepancy which exists between the figures and descriptions of the *A. Prevostii* under discussion, it is difficult to know what to accept and what to reject. All the available figures represent the molars of this specimen as follows: they have compactly placed crowns, narrow at the base and bearing three cusps, the median cusp slightly the largest; there is perhaps a trace of an internal cingulum appearing upon the anterior and posterior slope, but it does not overlap the base sufficiently to separate the crowns as in *Amphilestes*. The crowns are described by Professor Owen as quinquecuspidate, (Mes. Mamm., p. 14) and the formula is given I 3 C 1 pm. 6 m. 6. Mr. Lydekker gives the formula as follows[1]: I 4 C 1 pm. 4 m. 7. This is probably correct.

AMPHILESTES, Plate VIII, fig. 1.

The fourth specimen of *Amphitherium* was originally designated by Professor Owen[2] as *A. Broderipii*, but in his subsequent memoir, he tentatively proposed the name *Amphilestes*, which is undoubtedly valid, as distinguished from the type of *Amphitherium*, the only doubt being whether the genus may not embrace *Amphitylus*. This genus also has but four premolars.[3] The molar crowns, as viewed on the inner surface, are well separated from each other by the fore and aft extension of the basal cingula. "Each molar presents a large middle cusp, with a smaller but well developed and pointed cusp at the fore and back part of its base; the 'cingulum,' a part peculiar to mammalian teeth, plainly traverses the inner side of the crown, where it develops three small cusps, one at the base of the large external cusp, and the other two forming the anterior and posterior extremities of the tooth." (p. 16, Mes. Mamm.). These molars approach those of *Phascolotherium* in pattern. So far as preserved, the contour of the ramus of *Amphilestes* resembles that of *Amphitherium*. In both genera the coronoid is broad and rather low, and the condyle is on a level with or slightly below the molars. In *Amphitylus*, on the other hand, the condyle is pedunculate and considerably raised above the molar level, while the coronoid is narrower than in the above genus.

The three genera may be clearly distinguished as follows:

Amphitherium.	*Amphitylus.*	*Amphilestes.*
Type, *A. Prevostii*, De Bl.? pms $_{4}$ m $_{6}$	Type, *A. Prevostii*, Owen, i $_{4}$ c $_{1}$ pm $_{4}$ m $_{7}$	Type, *A. Broderipii*, Owen, i $_{4}$ c $_{1}$ pm $_{4}$ m $_{7}$
Molars bicuspidate, with a posterior heel; no cingulum between the molars; an internal cingulum; condyle on the molar level.	Molars tricuspidate, compactly placed; cingulum faint or wanting between the molars; condyle elevated and pedunculate.	Molars tricuspidate, separate, cingulum strong forming anterior and posterior basal cusps; condyle on the molar level.

[1] In a letter to me dated April 16th, 1887. See fig. 2a, *Amphitylus* upon a later page.

[2] Geol. Transactions, 2nd Series. Vol. VI, pl. 6, fig. 1.

[3] Mr. Lydekker (April 16th,) sends me the following formula: I 4 C 1 pm. 4 M 7.

Some doubt has been expressed[1] as to the generic separation of *Amphitylus* from *Amphilestes*. Although the dental formulas are the same, and the molars in each genera are tricuspidate, we cannot fail to admit that there is a more than specific separation involved in the development of the molar cingula and the shape of the articular portion of the jaw.

PHASCOLOTHERIUM. Plate VIII, fig. 3.

Although the single specimen representing this genus has been long known and often described, a review of its principal characters is necessary here. While separated from *Amphilestes* and *Amphitylus* by its mandibular characters and the entire absence of teeth of the premolar pattern, it is nevertheless clearly related to the line of these genera and of *Triconodon*, by the character of the molar crowns.

The genus is known from a single, well-preserved, right mandibular ramus from the Stonesfield Slate, the size and proportions of which indicate a strong animal. The angle and condyle are confluent, the former presenting a widely inflected border which has been partly broken away. The condyle is on a level with the molars; it faces backwards and is rather broad transversely; above this the border is deeply notched and rises into the powerful, recurved coronoïd process. The coronoid has a decided anterior rim which sinks below the alveolar border. In the lower part of the deep pterygoid fossa, thus bounded, is the dental foramen, and below this, the mylohyoid groove stretches forward and sinks beneath the fifth molar. The inferior border presents a single curvature from the condyle to the symphysis. The symphysial surface is partly fractured. The incisor border is elevated and the molar border depressed.

Close to the fractured symphysis, the fang of i_1 can be distinguished. The median incisor was apparently the largest, and the series decreased in size slightly towards the canine. The incisors are semi-procumbent, with long, straight fangs, expanding very slightly at the summit into a flattened crown, distantly resembling those of *Amblotherium* and *Phascolestes*, but quite different from the *Triconodon* incisors. The *canine* is erect, slightly recurved at the summit, and implanted by a stout cylindrical fang. The first molar is separated by a diastema from the canine and by a narrower interval from m_2. A close study of $\dot{m}_1$ shows that it possesses, in miniature, the characteristic features of the other molars, three cusps and a basal cingulum. We observe in other mammals of this period as many as six, seven and eight true molars; there is, therefore, no ground as regards number, either for describing the anterior teeth of this series of eight as prémolars, or, for calling this genus " typo dentate."[2] The fact that there are seven teeth of uniform pattern, when considered with the unusual presence of a diastema behind the canine and the comparatively short space

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[1] Mr. Lydekker in a letter to me, May, 1887.

[2] Mesozoic Mammalia, p. 115.

between the coronoid border and the canine, suggests rather that premolars were present in members of the ancestral line of *Phascolotherium*, and have disappeared in this genus, the true molars only having been retained. The diminutive size of m_1 and m_7 suggests that a still further reduction of the series is in progress at each end. The molar pattern consists of a prominent central cone with smaller anterior and posterior cusps sub-equal in size, upon its slopes. There is a very pronounced internal cingulum encircling the crown and rising into anterior, posterior and median basal cusps as in *Amphilestes*.[1] Faint vertical ridges may be observed upon the main cusp. According to the writer's observations the lateral cusps project partly from the inner slopes of the main cusp, and are not precisely in line.

TRICONODON, Plate VIII, fig. 4.

This genus, from the Purbeck, is represented by numerous remains of both jaws, and is therefore the best known of all the Mesozoic Mammalia. It is distinguished by many "recent" characters, and forms an important link between three of the Stonesfield Slate genera and some of the modern Marsupials.

As shown by Professor Owen, the mandibular rami vary in different species. In *T. ferox*, which has been selected as the type in this memoir, the lower border has a single downward curvature, slightly raised beneath pm_3. In *T. mordax* the angle of the jaw is slightly depressed below the condyle, but in *T. ferox* it is sharply and widely inflected so as to partially obscure the condyle, recalling the *Phascolotherium* jaw. The condyle is usually upon the molar level, or rather the level of the alveolar border; in some specimens, as in the *T. mordax* (Mes. Mamm., Pl. III, fig. 7), the strongly convex articular face of the condyle is directed backward; in another specimen, probably *T. ferox*, the condylar face was seen directed upwards (compare Mes. Mamm. Pl. III, fig. 2, B). The supracondylar notch in *T. ferox* is much deeper than in *T. mordax*. The coronoid process is in all cases broad and powerful with rather shallow fossae and a swollen anterior border. In the lower angle, on the inner face is the dental foramen, and from this the shallow mylohyoid groove extends forward near the lower border. The inner face of the ramus is vertically convex, and indicates great strength; the outer face is flat below the alveoli and bulges near the lower border. In some specimens (Mes. Mamm., Pl. III, fig. 7,) a shallow groove extends forward from the crotaphyte fossa; below this fossa is a ridge extending backwards to the outer side of the condyle. Below pm_2, in *T. mordax*, the lower border bends sharply upwards to form the stout chin; this character is unique among the mammals of the period.

Mandibular dental series in T. ferox. The *incisors* as preserved in this species and in *T. occisor* are represented by i_2 and i_3; there are also traces of the alveolus of i_1.

[1] The median basal cusps are slightly less prominent than in *Amphilestes*. They are omitted in the text and drawings given by Professor Owen, who describes the molars as "quinquecuspid," but may be seen in the figures given by Buckland, Bridgewater Treatises, Geology and Mineralogy, Vol. II, Plate 2.

The incisors are closely set so that the bases overlap; when complete, the series of the two sides probably formed two widely open curves; the crowns are pointed and recurved with a low posterior heel and uniformly convex anterior slope. The *canine* is lofty, slightly procumbent and recurved; the base of the outer surface is slightly grooved, but there is no trace of a double fang on the inner surface. The *premolars* are widely set but there is no distinct diastema; they have a uniform pattern; in most specimens pm_3 and pm_4 show a marked increase in size over pm_1 and pm_2. The pattern of pm_1 is well shown in *T. occisor* (Mes. Mamm., Pl. IV, fig. 2); it has a low obtuse central cusp, with a distinct internal cingulum, and anterior and posterior basal cusps which are slightly raised above it. In pm_2 (*T. ferox*), the central cusp is higher and the basal cusps more distinct. In pm_3 and pm_4 the central cusps are lofty, the internal cingulum pronounced and crenate, and the basal cusps much more elevated. The *molars* have a prominent serrate or indented cingulum embracing the inner face and the anterior and posterior slopes of the crown; in m_3 and sometimes in m_2, the cingulum forms a distinct cusp upon the posterior slope. The crown consists of three nearly erect conical cusps, set in line and partially confluent at the base. The posterior surfaces of the two forward cusps, *a* and *b*, are slightly less convex than the anterior, and the central cusp is the most elevated.

The maxillary dental series of T. ferox. A fragmentary maxilla (No. 47,788), which has been acquired since the publication of Professor Owen's memoir, contains the canine and three foremost premolars, and, excepting the upper incisors, completes our knowledge of the dentition of *Triconodon*, adding as an important character the bifanged upper canine. This specimen agrees in size and minor details with those which Professor Owen has referred to *T. Ferox*, but it is, of course, quite possible that one and all of these specimens belong to other species, the principal ground of correlation being similarity of size. The maxillary series have, in general, a uniform structure with the mandibular. They differ principally in the bifanged canine, in the presence of a cingulum on both the inner and outer surfaces of the molars and premolars, finally in the smaller relative size of pm^3. The *canine* is a powerful tooth, implanted by two stout fangs; the anterior border is convex and nearly vertically placed; the posterior is concave. The *premolars* are known from three specimens; the first (No. 47,788), presents the inner view of the canine and $pm^{1\text{-}3}$; the second (No. 47,778) gives the outer view of $pm^{3\text{-}4}$, also of $m^{1\text{-}2}$; the third (No. 47,779) gives the inner view of $pm^{3\text{-}4}$, $m^{1\text{-}2}$ and part of m^3. So far as these specimens overlap each other they agree in all essential characters, and we are justified in superposing them as in figure 4. In pm^1 the inner cusp has a faint indication of the anterior basal cusp, while the posterior basal cusp is much more prominent than in the lower molars; the prominent cingulum slightly overlaps the base anteriorly, and is produced into a cingulum cusp posteriorly. Pm^2 repeats these characters on a larger scale, with a greater distinctness of the anterior basal cusp. Pm^3 is only slightly larger than pm^1, and differs from it in the greater distinctness of the anterior basal cusp; the cingulum is well marked upon both the inner and outer surfaces (see also Mes. Mamm., Pl. III, fig. 18). In two specimens the anterior basal cusp of pm^4 is wanting; in the third (No. 24,778) it is faintly developed on the outer surface; this tooth is larger than pm^2, and has a pronounced and much indented cingulum. The *molars* resemble those of the mandible inverted; the central cusp is slightly the most prominent; the cingulum is bold and deeply indented. M^1, in (No. 47,779), is very instructive, as showing the manner of wear; the posterior surfaces of the cusps, *a* and *b*, are worn slightly concave, probably by the anterior faces of the cusps, *b* and *c*, on the lower molars. The external cingulum is also indented, and descends low upon the outer face of the crowns.

Varieties of Triconodon.—It is probable that the numerous specimens of *Triconodon*, as Professor Owen has suggested, represent several species. Besides the variations in the mandible which have already been described, we observe many differences in the forms of the teeth. In *T. occisor* the canine is nearly straight. The premolars vary in the development of the anterior and posterior basal cusps. The molar variations are still more marked; the molar cusps are sometimes erect, subequal in size and only partially confluent (Mes. Mamm., Pl. III, fig. 9); in other specimens they are retroverted (fig. 19); sometimes the middle cusp is much the highest (Pl. IV, fig. 2); the cingulum is in some cases smooth, in others it does not embrace the anterior and posterior faces of the molars; this seems in a measure to be due to age.

Of still greater interest are the variations in the number and succession of the molars, because they serve to connect the genus *Triacanthodon* with *Triconodon*, and to show that in *Triconodon* we have, in all probability, the same relation of milk and permanent dentition which we find in the modern marsupials.[1] The evidence for this hypothesis, which was suggested to the writer by Mr. Lydekker, is found in a comparison of a series of specimens beginning with *Triacanthodon serrula.* When these are placed in line, as in the accompanying cut, we at once observe a constant increase in size of the jaw taking place in direct proportion to the succession of the third and fourth molars. In the smallest of the series, *a*, *T. serrula* (Mes. Mamm., Pl. IV, figs. 7 and 8), behind three teeth of the premolar pattern are five teeth shaped like molars. The foremost of these is somewhat undersized, the hindmost m_4 is still in its formative capsule, and it is only owing to the fracture of the jaw that it is visible; the penultimate molar, m_3, is still partially covered by bone. The second of the series, *b*, is the specimen described as *T. occisor* by Professor Owen (Pl. IV, fig. 2); it is slightly larger; m_3 is only partially protruded as its third cusp is still covered by bone; the tip

[1] In describing the dentition of *Triacanthodon* (Mes. Mamm., p. 73), Professor Owen pointed out that the fourth tooth, counting from the canine, may belong to the deciduous series. In discussing with Mr. Lyddekker the question of uniting the above genera he suggested that the fully adult mandibular formula of *Triconodon* may be *pm* 4, *m* 4.

of pm_4 is just appearing above the alveolar border. The third of the series, *c*, is still larger, *T. ferox* (Pl. III, fig. 11), and we observe that m_3 is fully exposed and pm_4 has come fully into position. The fourth of the series, *d*, is *T. mordax* (Willett)[1]; it is slightly smaller than the third, there are two premolars and four molars, fully exposed in place. At the time this specimen was described by Mr. Willett[1], Professor Flower suggested two hypotheses to account for the extra tooth of molar form: (1), That the most anterior of these teeth represented the single deciduous premolar, d_4, which in the marsupials is molariform[2]; (2), That all the teeth preserved belong to the permanent set, when the dental formula will be *pm* 3 *m* 4, and indicate the most fully matured specimen as yet discovered. The writer adopts the second with the exception of the formula of *T. mordax*, which he believes to be *pm* 4 *m* 4, on the following grounds. It is evident that in *Triconodon*, as in the recent marsupial *Thylacinus*[3], the posterior molars are very late in coming into place; the first molar, in the specimen under consideration, resembles the other molars much more closely than does the anterior molariform tooth in *T. serrula*, and is therefore probably a true molar; in all the specimens of *Triconodon* thus far observed there are four premolars.

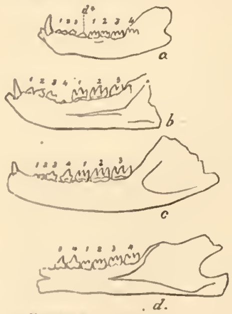

FIGURE 3. A series of *Triconodon* mandibles, all drawn natural size, representing the growth of the mandible in relation to the succession of the teeth. *a Triacanthodon serrula*, Owen. *b Triconodon mordax*, a young individual. *c T. mordax*, a somewhat older individual. *d T. mordax* (Mr. Willett's type), probably a fully mature individual.

The following hypothesis seems to conform to all the present evidence, *viz.:* the fully adult dental formula is *pm* 4, *m* 4; the single deciduous tooth is the fourth premolar, d_4, which is molariform; the fourth molar is very late in coming in.

According to this the *Triacanthodon serrula*, *a*, is an immature *Triconodon* with the formula *pm* 3 *d* 1 *m* 4, the fourth molar being still in its capsule. The *T. occisor*, *b*, is slightly older, the formula being *pm* 4 *m* 3 (m_4 still in its capsule). The *T. ferox*, *c*, is still older. The *T. mordax*, *d*, is fully mature with m_4 in place.

There is little or no doubt that the most anterior tooth of molar form in *T. serrula* is the fourth deciduous premolar, but we must admit that the balance of evidence derived from the majority of specimens belonging to *T. ferox* and *T. mordax*

[1] *E. W. Willett, Esq.*

"Quarterly Journal of the Geological Society," 1881, p. 378. Notes on a Mammalian Jaw, from the Purbeck Beds, at Swanage, Dorset.

[2] *W. H. Flower.*

"Philosophical Transactions." On the Development and Succession of the Teeth in the Marsupialia 1867, p. 638.

[3] *Flower.*

Op. cit., p. 639.

is that the fourth molar does not come into place at all; in several of these specimens the jaw is to all appearance fully mature. It may be that in some species m_4 is more retarded than in others. While therefore the evidence as a whole favors the above hypothesis, there remains the possibility that m_4 is wanting in *Triconodon* and characterizes the allied genus *Triacanthodon*. In such case the *T. mordax*, Willett, should be added to the latter genus.

AMBLOTHERIUM, Plate IX, fig. 11.

When the genera *Amblotherium*, *Achyrodon* and *Phascolestes* are placed side by side, as upon Plate IX, a striking general resemblance is at once observed. This is extended when the dentition is carefully examined. The molars especially are essentially similar in form and number and distantly recall those of *Amphitherium*. *Amblotherium* is the best preserved and most representative member of this little group. It is known from two well-preserved mandibular rami which belong to different species and enable us to determine all the characters of the lower jaw as seen upon the internal surface. The figure is taken from *A. soricinum*[1], (No. 47,752.). The condyle is raised above the molar level, upon a broad condylar process. The angle is slender and slightly inflected at the tip, as in *Amphitylus*; a ridge extends from this to unite with the thick anterior border of the coronoid and thus bounds the deep pterygoid fossa. In the angle thus formed is the dental foramen from which the mylohyoid groove reaches forward to the symphysis. The inferior border of the ramus has a double curvature and ascends anteriorly, tapering to the symphysis. The symphysis is long and narrow and the incisor border is well raised, while that of the premolars is depressed. There are four incisors, a canine, four premolars, six molars with the impression of a seventh *in situ*. The whole dentition is rather weak, the incisor-canine series especially so. The incisors are widely separated, with slightly expanded sub-recurved crowns set upon slender fangs; they decrease in size from i_1 to i_4, the latter being very small. The canine is a slender, recurved tooth, with a single contracted fang. The *premolars* increase rapidly in size from before backwards; pm_1 is a minute tooth of the premolar pattern most prevalent in the mesozoic mammals, *i. e.*, a recurved crown, bifanged, with a low posterior heel and a faint internal cingulum; in pm_3 the heel is more prominent; pm_4 has a high crown and less distinct heel. A characteristic feature of the *molars* is the absence of an internal cingulum. They increase in size from m_1 to m_4 and then decrease; they are all bifanged and have a uniform pattern. The third molar is typical of the series; the crown supports a high central and two lateral cusps; the central cusp is high, pointed and slightly recurved; the anterior cusp is directed obliquely forwards and upwards, while the posterior has rather the character of a basal heel, which is over-

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[1] There is little doubt that some of the specimens referred by Prof. Owen to *Amblotherium*, belong to *Stylodon* or the *Stylodontidæ*, with a styloid external cusp.

lapped by the anterior cusp of the succeeding molar. In old individuals (Mes. Mamm., Pl. II, fig. 2), the central cusp is worn nearly to the level of the anterior cusp, and the molars resemble those of *Phascolestes.*

PHASCOLESTES, Plate IX, fig. 12.

This genus is represented by the anterior portion of a left mandibular ramus (No. 47,741). Professor Owen proposed the name with some doubt as to its value, since he was inclined to associate the specimen with *Peralestes*, a genus represented only by an incomplete maxillary fragment (p. 35, Mes. Mamm.) Such an association seems to the writer unsafe and improbable on the following grounds, which will be made clear by a comparison of figs. 8 and 12: (1), There are six molars, and possibly five premolars in the *Peralestes* maxilla, and eight molars and four premolars in the *Phascolestes* mandible; (2), The *Peralestes* (upper) molars have separate opposed *i. e.* internal and external cusps, the highest of which is internal, while in the *Phascolestes* (lower) molars there is no indication of the presence of separate opposed cusps; (3), We find in another genus, *Peraspalax*, a mandibular dentition of the very character which we should anticipate to find opposed to the *Peralestes* dentition.

There are some reasons for uniting *Phascolestes* with *Amblotherium.* The worn molar crowns of the *Phascolestes* mandible indicate a rather older individual than that to which the *A. soricinum* mandible belonged. The resemblances between the two genera, as seen upon the internal face, are in the molar, premolar and incisor patterns, and in the curvature of the alveolar border. The differences are still more important, *viz.*: that while the matrix impressions of the *Amblotherium* molars show no trace of external cusps, the last three missing molars of *Phascolestes* have left impressions of styloid external cusps similar to those of *Stylodon*, or "the impressions of three successive long and slender cones," as described by Professor Owen, (Mes. Mamm., p. 35).

The principal characters of the *Phascolestes* mandible and dentition are the following: The symphysis is long and the incisor alveolus is elevated. The *incisors* are equidistant; i_1, is much the largest, the tip of the crown is wanting and the fang is faintly grooved; i_2 is a small tooth with a slender fang and expanded crown; i_3 is slightly larger, and i_4 is nearly double the height of i_2. The canine is high, pointed and recurved, with a broad fang, grooved upon the inner surface. The first *premolar* is rudimentary; pm_2 has a double fang, a well-worn crown and a low posterior heel; pm_3 also bifanged, with a high recurved crown and prominent posterior heel like that in the Amblotherium pm_3; pm_4 has a blunt conical crown, with a distinct cingulum and faint posterior heel. The first *molar* is extremely minute; m_2, m_3 and m_4 have a high central cusp with a well-raised anterior cusp and a posterior sloping heel. Behind the fourth molar is the cast of m_5; and, according to Prof. Owen, the casts of the styloid external cusps of three succeeding molars.

ACHYRODON, Plate IX, fig. 13.

As was fully recognized by Professor Owen, the molars of the minute *Achyrodon* are of the *Amblotherium* type, but the genus is well distinguished by the acuteness of the cusps and the elevation of the premolars. The specimens consist of portions of four mandibular rami, the most perfect of which (No. 47,745) is represented in the figure. This is *A. nanus*, (Owen). The ramus is mutilated at the extremities, but preserves two premolar casts followed by two premolars and eight molars *in situ.* The posterior half of the symphysis is preserved, and from this the mylo-hyoid groove extends backwards to, and seems to perforate the border of the pterygoid fossa. Judging by the portion preserved, this fossa was divided into an upper and lower basin by a median ridge. Below the dental foramen is a lower ridge which extended into the angle. The coronoid border rises abruptly behind the last molar. The *premolars* are lofty and supported upon two fangs. The most anterior in this specimen is probably pm_3, it has a very high crown, with a convex anterior and nearly vertical posterior slope, it has a pronounced cingulum, which slopes obliquely backwards and encircles the crown; the last premolar has an equally high but more slender crown, rising to double the height of m_1; the cingulum is less decided but embraces the base of the crown as in pm_3. The coronal patterns of molars $_{(1-7)}$ are exactly similar; there is no cingulum; there is a high central cusp sloping forwards with a waving contour, and produced to a sharp point; from its base rises freely the sharp and prominent anterior cusp and the low and comparatively blunt posterior cusp, which is, however, more elevated than in *Amblotherium.* The molars overlap each other. The first molar is relatively larger than in the allied genera; the series increases gradually in size from m_1 to m_6. The last molar lacks the posterior cusp.

From the matrix impressions observed by Professor Owen in another specimen (Pl. II, fig. 8; p. 40, Mes. Mamm.), it is probable that there were three or four incisors, a canine, four premolars and eight molars.

LEPTOCLADUS. Plate IX, fig. 10.

This Purbeck genus is represented by a single fragment of a left mandibular ramus, with the outer surface exposed, and containing eight molars. Professor Owen (p. 53, Pl. III, figs. 4, 4ᵃ. Mes. Mamm.), placed it as *incertæ sedis* near *Stylodon,* remarking, however, that he considered this relationship somewhat doubtful. A very careful examination of this specimen, the results of which are expressed in the figure, shows that it is very remote from *Stylodon;* and, so far as known, represents an entirely unique type of dentition. The molars are seen upon the outer surface, and it is possible that a view of the inner surface would reveal the presence of internal cusps similar to those of the *Peraspalax* molars. The main molar cusp of each suggests a resemblance which is lessened by a close comparison of the molar pattern as a whole. When the dentition of *Leptocladus* is carefully compared with that of each of the mesozoic mammals, the nearest relationship suggested is to *Amblotherium*. *Leptocladus* approaches this genus in its dental formula (*pm*4 *m*6), and differs from it and its allies in the suppression of the anterior lobe of the molars which is replaced by a cingulum cusp.

The ramus has a nearly straight lower border; below the first premolar it curves upwards rapidly. The outer surface is convex and shows two foramina beneath pm_2 and m_1. The alveolar border is depressed below the premolars and rises in the middle of the molar series, this curvature resembling that in *Phascolestes*. Professor Owen discovered traces of two *incisor* sockets; these teeth were probably small, compactly placed, and not widely separated from the canine. Judging by the socket, the *canine* was a large, erect tooth. The succeeding four teeth are evidently premolars; they increase rapidly from the first to the fourth; there is a minute cusp upon the anterior slope and a posterior heel which varies in width; the absence of an external cingulum separates them from the molars. The premolars of mesozoic mammals invariably lack the external cingulum. There are probably six bifanged molars, two of which filled the space between m_4 and the coronoid process. The first molar has a conical, central cusp and a broad posterior heel; on the anterior slope, the cingulum forms a basal cusp, and, disappearing below the main cusp, reappears at the side of the posterior heel. In m_2, m_3 and m_4, the main cusp is tall, slender and slightly recurved, while the posterior heel is very broad and much worn.

PERAMUS. Plate VIII, fig. 6.

In *Peramus* and the genera which, although not closely affiliated, will be considered along with it, *viz*, *Spalacotherium*, *Peralestes* and *Peraspalax*, all from the Purbeck, we meet a new principle in the construction of the molars. There are still three cusps, but these cusps are not arranged in the same fore-and-aft line; owing either to the rotation inwards of one or more of the cusps, or to the elevation of the internal cingulum. We find the crown of the tooth broadening to support internal and external or opposed cusps.

The chief materials for the determination of the characters of this genus consist of portions of two mandibular rami. In the type specimen (No. 47,742, Brit. Mus.), the posterior half of the ramus is preserved; in the second specimen (No. 47,743) the anterior half of the ramus is preserved; both specimens preserve the first molar intact with some of the adjoining teeth, and we are thus enabled to place these halves together and reconstruct the jaw, as seen in figure 6. Another mandibular fragment (No. 47,743), preserving the canine and portions of the premolars and incisors, has been placed with *Peramus* by Professor Owen (Pl. II, fig. 11), but in the absence of a molar tooth, this determination is uncertain on the following grounds: the fifth and sixth premolars of this specimen have conical crowns, with a narrow base, whereas in the type specimen, pm_6, is bifanged with a very broad base and anterior and posterior basal cusps. A fourth specimen (fig. 13, Mes. Mamm.) may, however, be safely referred to *Peramus*, but, unfortunately, it adds little to our knowledge of the dentition. The jaw of *Peramus* is quite unique. The coronoid process is very high and tapers as it ascends; its summit is fractured, but a faint cast indicates a rounded contour; its anterior border descends in a ridge which extends along the outer face of the ramus beneath the molars. The condyle is on the molar level and terminates a ridge. Below this, the border descends into a triangular process which, according to Professor Owen, is sharply inflected and thus represents the angle. This observation cannot now be confirmed as this process has been broken away. The ramus tapers anteriorly but less so than in *Stylodon*. There is a foramen below the first and second premolar. The fourth specimen seen upon the inner surface shows a mylohyoid groove.

In the matrix of the anterior portion of the type specimen there can be distinguished a faint cast of the canine; behind this are traces of nine teeth, six of which are premolars; the paucity of molars is a unique feature not elsewhere observed among the mesozoic mammalia of this type. The sixth tooth is counted among the molars by Professor Owen, but it has a distinctively premolar pattern and lacks the elevated anterior cusp of the true molars. The premolars increase from first to last; they all show the usual recurved crowns and low posterior heel, while pm_{4-6} have anterior basal cusps indicating the presence of a strong internal cingulum. The pattern of the three *molars* is substantially the same, m_2 being the typical tooth of the series. It has a high central cusp with a strongly convex outer surface; from the base of its posterior slope rises a prominent heel, while from the upper internal surface of its anterior slope rises a small cusp; this cusp, although rotated inwards, is accessory to the main cusp and is not an independent inner coronal cusp, such as that in the *Peraspalax* molar, as Professor Owen's description (p. 41) and figure 10 c (Pl. II) would indicate; a minute cusp at the base of the anterior slope probably points to an internal cingulum, and we may conjecture that the inner surface of this crown was broad and shelf-like. *M* and m_3 are slightly smaller than m_2, and the anterior basal cusp, if present, is faint.

Since the above was written, much evidence has come to hand that the number of premolars in all the mesozoic mammalia never exceeded four. This rule is so universal that it seems unlikely that *Peramus* should form the single exception. It is therefore possible that when the inner faces of the teeth are discovered, those determined as pm_5 and pm_6 will prove to be m_1 and m_2 and the formula will stand *pm* 4, *m* 5.

SPALACOTHERIUM. Plate VIII, fig. 7.

This genus, from the Purbeck, is represented by numerous mandibular fragments with well-preserved teeth. The two here chosen and combined for illustration as types, are: first, the left ramus (No. 47,750, Brit. Mus.), figured by Professor Owen in Pl. I, fig. 38, this has five molars with the somewhat doubtful impression of a sixth; second, the ramus represented by Professor Owen, in figure 34, with two incisor impressions, the canines, four premolars and one molar well preserved, with the impressions of several succeeding molars. There are two chief grounds to justify the placing of these fragments together as represented in figure 7, the anterior half being left in outline. They naturally involve the question of the molar formula, and of the number and character of the premolars, and need therefore to be fully stated: first, in specimen No. 47,749, figured by Professor Owen (fig. 37), there are the distinct impressions of pm_3 and pm_4, and two complete molars, m_3 and m_4, besides impressions of four others m_1, m_2, m_5 and m_6; the premolar impressions in this specimen conform with the crowns of the original of fig. 34, and show conclusively: (a), that the premolars were entirely unlike the molars; (b), that there were six molars and four pre-molars; second, the specimen figured in fig. 33 (Mes. Mamm.) confirms the above, as it includes two incisors, a canine and ten teeth behind it. This result differs from that reached by Professor Owen.[1]

There were at least three *incisors* (p. 26, Mes. Mamm.); two of them, i_2 and i_3, are represented by distinct impressions which indicate that they were compactly placed, with pointed recurved crowns. In figs. 33, 40, 41 (Mes. Mamm.) the lateral incisor is erect. These teeth and the rather slender recurved canine resemble the corresponding teeth in *Triconodon*, rather than those in the *Amblotherium* or *Stylodon* series. The *canine* is rather slender, vertical, recurved at the summit, and apparently bifanged. The *premolars* have the typical number, four, and increase in size antero-posteriorly. The crown is implanted by two fangs, with a convex anterior and concave posterior slope; the cingulum forms an anterior basal cusp, but extends slightly below the posterior basal heel, which is unusually prominent. The *molars* are very unique in pattern; they present three cusps, the anterior and posterior cusps being rotated inwards. The outer surface presents a high vertical and symmetrically convex main cusp, with a faint cingulum near the base; from its anterior and posterior slopes project the lateral sub-equal cusps which are confluent below with the general convexity of the crown; on the inner aspect these cusps are seen to be rotated inwards and to spring in part from the shelf-like plane surface of the crown as two cones with widely divergent apices. The shelf at the base of these cusps may be considered either as a broadened cingulum, or as a wide cusp-bearing base, such as is seen in some primitive bunodont molars, *e. g. Palæochærus*. The

[1] The premolars are correctly represented in figs. 35 and 36 (Mes. Mamm., Pl. I), and conform with my drawing. In figs. 33 and 34 they are incorrectly drawn, as shown by comparing them with the impressions of four recurved premolar tips in fig. 32 (No. 46019). Part of the figures thus give a false idea of the dentition which Professor Owen's description does not clearly remove, *viz:* that the molar pattern is a development of the premolar pattern, and that the premolar-molar dentition is homodont.

second and third molars are the largest; behind these the teeth gradually decrease in size.[1]

The *ramus* of *Spalacotherium* is very long and shallow, with a single main curvature from the condyle to the symphysis. The most distinctive feature is the remarkable elevation of the condyle and its confluence with the angle; in the latter respect this genus approaches *Triconodon* and *Phascolotherium*, but the condyle is much more elevated than in either of these forms. The condyle is broad transversely, and from its inner face a somewhat fractured ridge, representing the angle, extends forwards and downwards to the dental foramen. The pterygoid fossa is thus very deep, but contracted vertically. The mylohyoid groove disappears beneath the fourth molar. Another marked feature of the ramus is its contraction beneath the last molar. The lower border extends forwards without bending upwards at the symphysis.

PERALESTES. Plate VIII, fig. 8.

This genus is represented by a portion of a right maxilla, seen on the outer face, containing the last premolar, six molars and the alveoli of an incisor, the canine and three premolars. The distinctive feature of the genus is the molar pattern, in which we find a complete opposition of internal and external cusps, a further development of the partial opposition observed in *Peramus* and *Spalacotherium*.

The portions of the maxilla which remain are entirely uncharacteristic. In the forward fragment we can distinguish a part of the premaxilla with the small alveolus of the lateral incisor; behind this a large alveolus belongs probably to the canine. Then follow two pairs of sockets, in the second of which are traces of fangs; here were probably inserted pm^1 and pm^2. Behind this is a fractured interval with space for two premolars of increasing size.[2] A portion of the bony palate is preserved in the specimen (Pl. II, fig. 3, Mes. Mamm.), which shows that this interval has not been greatly increased by fracture, so it seems possible that there were five premolars (see *Peraspalax*). We may, however, provisionally regard the last premolar as pm^4. This tooth is much more elevated than m^1; the crown is supported upon two widely set fangs, with a broad base contracting above the cingulum in a pointed and nearly vertical cone. Behind this are five molars, of nearly uniform pattern, followed by a sixth of smaller size and rather obscure pattern. The crowns increase in height from m^1 to m^4, and then rapidly diminish. The marked feature of the crown is the lofty

[1] There is again a considerable discrepancy between the drawings accompanying Professor Owen's Memoir, and those here given. So far as the writer's observations went the enlarged molars, (Pl. I, figs. 32 B and 34 B) are decidedly incorrect. By a comparison of figure 7 with those in Pl. I, No. 38, both from the same specimen, the reader can observe the errors of the draughtsman in the latter. Figure 7, and the enlarged molars in the text, do, however, approximately conform with the partly broken molars represented in fig. 36, A 5, Mes. Mamm., and those in fig. 38. What is more important they correspond with Professor Owen's description (p. 24), which shows that he himself clearly understood the characters of these teeth.

[2] These alveoli are mentioned in Professor Owen's Memoir, p. 33, but not studied in detail. A very careful examination of the maxillæ brings them out clearly as figured.

antero-internal main cusp, *c*, which is stout to the apex and slightly recurved; behind, and slightly external to this, is the postero-internal cusp, *b*, which is about one-third the height of *c*; opposite the antero-internal cusp the crown is very broad, while it narrows to one-half the breadth posteriorly; it is thus sub-triangular in horizontal section; the main cusp, *c*, has an outer concave slope leading to a longitudinal depression, beyond which the crown rises into the low antero-external cusp, *a*; from *a* the outer border slopes posteriorly into the serrate margin, *d*, opposite the postero-internal cusp. The position and height of the antero-external cusp, *a*, varies in m^2 to m^5; it is quite distinct.[1]

The genus *Peralestes* is obviously related to *Peraspalax*, in which we find also, in this case, in the lower molars, the complete opposition of cusps. After a description of *Peraspalax*, the points of similarity and difference between these forms will be discussed.

PERASPALAX. Plate VIII, fig. 9.

This genus is also known from a single specimen, an incomplete mandibular ramus, with seven teeth *in situ*, and the impressions of three others. The portion of of the ramus preserved, as seen on the inner surface, is stout and well rounded, and below the canine is a partial impression of the chin which bends upwards, like that of *Triconodon*, indicating that the incisors were nearly erect. These robust features of the jaw, taken together with the structure of the molars, seem to place *Peraspalax* in the line of the modern *Dasyuridæ*.

Judging from the cast, the canine was stout and recurved, like that of *Triconodon*. At a short distance is the impression of a small premolar, which was probably pm_2, as the interval is broad enough for a small pm_1. The second premolar had a low, recurved crown with a broad heel; pm_3 had the same pattern slightly enlarged; pm_4 is bifanged with a high, conical crown, and strong internal cingulum; this forms an anterior basal cusp, and posteriorly encircles the base of the posterior cusp. This elevation of the posterior cusp of the last premolar above the cingulum is observed in all the supposed carnivorous genera of the mesozoic period. Behind this premolar is a narrow gap, which was probably filled by a true molar as there is barely space enough for a premolar of the same proportions as pm_4. The drawing (Pl. II, fig. 9), accompanying Prof. Owen's memoir, gives an incorrect impression of these molars. In the specimen a portion of the external cusp of m_4 is preserved, and a cast of the same cusp in m_5; this fact, taken with the fully preserved molars m_6 and m_7, leaves no doubt that the molar pattern was uniform, and that the cusps seen in m_2 and m_3 are the internal cusps, the external cusps having been broken away. The typical molar pattern is seen in m_5; there is a high, pointed, antero-verted external cusp *a*, and directly opposite it, on the inner side of the crown, a low conical cusp *b*;

[1] For the details of the *Peralestes* and *Peraspalax* molars, see the cut illustrating the typical molars of mesozoic mammals, under heading CLASSIFICATION.

the anterior and posterior borders of the basin between these cusps are raised into prominent basal cusps *c* and *d*; there is also a posterior cusp at the base of the crown *e*. The internal cusps, *b*, are broad in the anterior molars and become more pointed posteriorly; the reverse order is true of the external cusps, *a*. A peculiar feature of the series is the overlapping of the posterior by the anterior cusps. These molars resemble the third lower molar of *Didelphys*, but lack the external basal cusp of the latter.

The relations of Peralestes and Peraspalax.—The writer's grounds for not following Prof. Owen in referring the *Phascolestes* mandible to *Peralestes*, have already been given (*vide* PHASCOLESTES). In the jaw of *Peraspalax*, however, are lower molars which closely correspond to what we should expect to find in opposition to the *Peralestes* upper molars. These genera are the only ones among the British mesozoic mammals, as yet discovered, with fully opposed cusps[1]. Not only so, but the molar crowns in both genera reverse the usual arrangement of the higher and lower cusps, *i. e.*, in the upper molars (*Peralestes*) the highest cusps are internal and retroverted; in the lower molars (*Peraspalax*) the highest cusps are external and antero-verted. It would appear from this that in each the arrangement of higher and lower cusps is as in *Didelphys* and *Sarcophilus*. The type maxilla and mandible also agree approximately in size. So far as the pattern of the molars and premolars is concerned there is, therefore, every reason to believe that these specimens belong to the same genus, but the number of the molars and premolars presents a difficulty. The series are unfortunately incomplete in both specimens, and we have provisionally attributed these formulæ: *pm* 5, *m* 6, *Peralestes*, *pm* 4, *m* 7; *Peraspalax*, the whole number agreeing in each case, but the division differing. It is, however, possible that the interval between pm_2 and the last premolar in *Peralestes* has been widened by fracture, and that but one premolar was present there; or, that the space behind pm_4, in *Peraspalax*, held a small premolar; or that the upper and lower formulæ differed; either alternative would enable us to unite these genera without further hesitation. As the matter now stands the safer course is to keep them separate.

STYLODON, Plate IX, fig. 14.

The genus *Stylodon* is known from numerous mandibular fragments, undoubtedly representing more than one species; of these *L. pusillus* (No. 47,757) is here selected and figured as a type. In this genus we find a wholly different type of dentition from those we have been considering.

The jaw is very slender and tapers to the symphysis; there are two mental foramina beneath the anterior premolars and the canine. The contour of the coronoid process, judging from a matrix impression, is wide and high, and enough of the posterior border and angle is preserved to show that the condyle was below the molar level. The *incisors* in *L. pusillus* are very procumbent. The median incisor is much

[1] Leaving out of view, of course, *Plagiaulax* and *Bolodon* as belonging to a widely different *phylum*.

the largest; it continues the line of the lower border of the jaw; the crown broadens towards the tip and is flattened upon the upper surface. The series diminishes in size towards the canine, while the inter-spaces increase, and, judging by the fang, which is all that remains of i_4, this tooth was diminutive. The *canine* has a high, strongly procumbent crown; its fang is slightly grooved (No. 47,757), and in another specimen (No. 47,758) there are two distinct fangs. There are four bifanged *premolars*, which increase rapidly in size posteriorly; pm_{1-2} are broken; pm_3 has a high, recurved crown with a simple convex anterior slope, and a low posterior heel; pm_4 has a slightly stouter crown, and a broad posterior heel. The apparently single-fanged, styloid molars suggested to Professor Owen the appropriate name of the genus; there are seven distinct molars, with the indications of an eighth, in one specimen, (Mes. Mamm., p. 52, Pl. II, fig. 18*a*).

External aspect of the molars. The first molar is low and obtuse, with a broad base, and is distinguished from the premolars principally by its single fang; the cingulum rises anteriorly into a faint basal cusp. The second molar has a broad fang and rather stout conical crown, with a distinct cingulum; m_3 is nearer the typical molar pattern, the cingulum rising anteriorly; m_4 is a typical styloid molar, with a rather narrow base, distinct cingulum and lofty tapering crown; m_5 and m_6 are slightly smaller, while m_7 is a much smaller tooth.

In another specimen, (No. 47,758), the molars are still more slender and tapering. Unfortunately none of the specimens present the inner surface of the ramus, but much additional knowledge of the molars is derived from jaws in which the teeth are partially rotated in their sockets. Thus in Pl. II, fig. 18*a*, Mes. Mamm., we see that the crown is not actually styloid but rather chisel-shaped, with its greatest diameter transverse and the wearing surface sloping obliquely inwards and downwards from the outer tip. In fig. 19, Pl. II, an internal cusp upon m_7 is represented, and in fig. 15*a*, the molars are more compactly placed, and m_5 has an internal heel. In Pl. III, fig. 2, $m_?$, the molar is nearly in side view, and shows what may represent part of an inner fang. This accords with the conjecture of the writer, that these molars are not single-fanged, but have two fangs placed transversely, as in the upper molars of *Kurtodon.*

Since the above was written Professor Marsh has discovered the full pattern of the *Stylodon* type of molar, *viz*, a styloid external and tricuspid internal face, which renders it probable that some of the specimens attributed to *Amblotherium* and other genera, present the internal mandibular aspect of *Stylodon*, or an allied genus.

KURTODON, (*Gen. Nov.*)[1] Plate IX. Fig. 15.

The type of this genus is the single maxilla (No. 47,755) which was referred by Professor Owen to *Stylodon* (Mes. Mamm. p. 48. Pl. II, fig. 14.)

[1] The name *Athrodon* was at first assigned to this genus (Proc. Phila. Acad. June, 1887), but is found to be preoccupied by Sauvage (Bull. Soc. Geol. 1880, p. 530). *Kurtodon* was substituted later, (Am. Nat., Nov., 1887.)

Enough of the palate is preserved to show that the inner surface of the teeth is the one exposed. The fragments of bone in front of canine cannot be recognized as incisors. The *canine* is proportionally large, directed backwards and recurved, with a faint median groove, which may indicate a double fang. Behind this is a small, columnar premolar; a space which may have been occupied by pm^2, or may represent a diastema, follows; the premolar behind this is extremely small and functionless, and from this we might infer that pm^2 was permanently missing; pm_3 is slightly larger and bifanged, (Mes. Mamm., p. 49); pm_4 may be distinguished from the molars by the absence of a cingulum, but it is most interesting to observe that it is apparently in course of transformation into the molar pattern, the two fangs are not set in the line of the ramus, but obliquely, and the long diameter of the crown is also slightly rotated into a transverse position, with its apex internal. The seven *molars* are nearly uniform in size and very similar in pattern. They slightly increase in size from the first to the fourth and fifth, and then diminish; there is a corresponding downward curvature of the wearing surfaces. The inner line of the crowns is concave, and the outer, convex; this curvature is shown to be natural, and not the result of pressure, by the wedge-shaped sections of the crowns (fig. 4) the inner faces being much narrower than the outer, and the proximal surfaces closely applied to each other. The crown is supported upon two powerful fangs, placed transversely to the jaw; the convex inner slope is marked by a faint cingulum and rises to a narrow point, so that the direct internal view resembles that of the *Stylodon* molar; judging from the contour of the wearing surface, the outer slope is divided by a vertical groove, *g*; the summit of the crown slants obliquely outwards from the internal tip, but the tooth is so obliquely placed in the maxilla that the wearing surface is not far from the horizontal plane; this surface is concave from side to side, and, under a close examination, reveals a complex pattern: two enamel ridges, *e*, diverge from the inner apex of the wedge, along the sides of the crown, becoming thinner and less prominent towards the outer surface; from the inner angle of the Λ thus formed, a median ridge, e^1, traverses the crown, which is also less prominent as it extends outwards, dividing the surface into two valleys opening outwards. The crown is thus divided into transverse ridges and grooves like that of a rodent, but the resemblance is not complete since the median ridge is not the result of an infolding of the side of the crown, but is apparently the remnant of a folding of the enamel on the wearing surface, which will disappear in course of further attrition. A partly worn *Phascolomys* molar presents a somewhat similar appearance, (fig. 15, B e, e^1). This description of the molar pattern differs widely

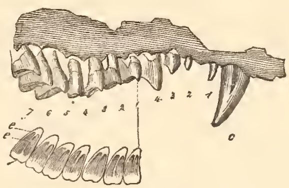

FIGURE 4. The inner surface of the left maxilla of *Kurtodon pusillus*, enlarged 5½ diameters.

from that given by Professor Owen (Mes. Mamm. p. 49). The additional details discovered in these crowns are of great interest; they indicate that there was a regular fore-and-aft or side to side grinding motion between the molars, such as is observed in the Rodents or in *Phascolomys*; this inference is strengthened by the rudimentary character of the premolars, the presence of a diastema, and the transformation of pm^4 into a molar which is apparently in progress. Upper molars of this character are invariably opposed by homologous lower molars with the pattern of the wearing surface reversed. The mandibular series of *S. pusillus*, the type specimen, present many points of difference: there is no diastema; the premolars are erect and functional; the molars are set in a straight line, they are slender and widely separate from each other (fig. 14; see also Mes. Mamm., Pl. II., fig. 18, A); the series are not subequal in size, but diminish in both directions from the middle molar, In *Chrysochloris* the insectivore selected by Professer Owen as most nearly approaching the *Stylodon* type, the tricuspid upper molars are separate, they interlock with the tricuspid lower molars, (the patterns being reversed) and the motion of the jaw is vertical, but in *Kurtodon* there are, strictly speaking, no cusps, and the action of the jaws must have been chiefly horizontal. There is thus no real homology between the *Kurtodon* and *Chrysochloris* dentition. The separation of this genus from *Stylodon* was made before the complete patterns of the *Stylodon* molar was known; now that it is fully known it is clear that the two forms belong not only to distinct genera, but to distinct families. Among the mandibular specimens which have been referred to the *Stylodon*, and thus figured by Professor Owen, (for example, fig. 3, Plate III.), there may be some which belong to *Kurtodon*.

BOLODON, Plate IX, fig. 16.

Since the publication of Professor Owen's memoir, another specimen, from the Beckles collection, has been received in the British Museum, which supplements the type specimen (47,735), and gives us the complete upper dentition of this very interesting genus. Through the kindness of Mr. Davies and Mr. Smith Woodward, this new specimen, which the writer found partly covered with the matrix, was fully exposed, and the important characters of the full series of true molars were brought out.

Bolodon is thus known from portions of two right maxillæ, one of which is complete anteriorly, the other posteriorly. Fortunately they preserve the following parts in common, as determined by the writer: the malar portion of the zygomatic arch, the maxillo-premaxillary suture, also the first, second and third premolars and first molars; these parts agree in every particular, and justify our placing the two specimens together, as is done in the figure. The question of the maxillary suture is naturally very important in its bearing upon the dentition of *Bolodon*. Professor Owen left the matter somewhat in doubt (p. 55). After carefully cleaning his type specimen (Pl. III, fig. 5), and examining it in a strong light, no doubt remained as to the presence of a suture behind the second tooth preserved. This result was confirmed by an examination of the second specimen, in which a fracture has taken place along the same line and left a distinctly serrate, sutural edge. The two foremost teeth, it follows, are in the premaxilla, while the diastema and the seven teeth behind it are in the maxilla. The anterior border of the premaxilla is smooth and rounded, sloping obliquely backwards; the outer face bulges around the fang of the large vertical incisor. Above the diastema, the maxilla is slightly concave, and then swells out into the widely arching zygomatic process; the infraorbital foramen is above the third premolar.

The foremost incisor lacks the tip of the crown; it is strongly convex and vertically placed, with a straight anterior edge and a small cusp upon the slightly oblique posterior cusp. The second incisor has a comparatively low, simple, pointed crown with anterior and posterior accessory cusps; it apparently lacks the vertical surface grooves which are so conspicuous on the premolars. Behind the suture is a wide, smooth diastema with no apparent trace of an alveolus. The three teeth which follow are evidently premolars, as they are well distinguished from the remainder of the maxillary series. It is uncertain whether they possess one or two fangs. The crowns are oval in section, with the short axis transverse; they are compressed towards the tip and bear three sub-equal cusps, equidistant, one anterior and two posterior. The posterior cusps are opposite, giving the tooth a bicuspid appearance in outer and inner view[1] (Mes. Mamm., Pl. III, fig. 6 B). There is an internal cingulum, but no external cingulum was observed. The sides of the crown are marked by grooves, which converge at the summit. In both specimens the third premolar is slightly smaller than the first and second. The four *molars* have comparatively low and elongate crowns. There is a prominent cingulum upon the outer face, which partly embraces the anterior and posterior slopes of the crown. The crown supports a double longitudinal row of small cusps. In the outer row of the first, second and third molars there are three cusps; in the fourth molar there are only two outer cusps, which are somewhat more prominent. In the inner row of the first, second and fourth molars there are three cusps, while the third molar has four cusps in the inner row. Each of these cusps is a minute cone, with faintly grooved sides. In the third and fourth molars there is a well worn, longitudinal groove between the inner and outer rows which cuts into the inner slopes of the cusps. In the first and second molars, on the other hand, there is no trace of such a worn median groove, but the whole inner face of the tooth,

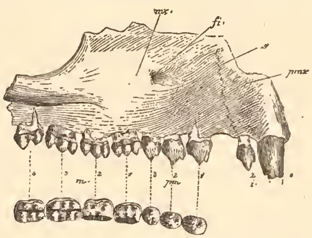

FIGURE 5. The outer surface of the right maxilla of *Bolodon*, enlarged 4 diameters.

[1] Professor Owen was misled by this bicuspid appearance in a fragmentary specimen (fig. 6), and described the two premolars as molars.

as far as the tips of the inner row of cusps, is worn smooth; in the second molar, in fact, the inner row of cusps is nearly obliterated.

This dissimilar attrition of the crowns of the anterior and posterior pairs of molars is a very puzzling faet. It would seem to indieate the presenee of two kinds of lower molars, the first pair of a trenchant charaeter, the second pair of a pattern somewhat similar to that in m^3 and m^4.[1]

Notes upon the genera *Microlestes, Plagiaulax* and *Stereognathus* are given under the next section.

II. THE CLASSIFICATION AND ZOÖLOGICAL RELATIONSHIPS OF THE MESOZOIC MAMMALIA.

Our materials for the purpose of classification are very limited. The greater number of genera are represented merely by the mandibular dentition between the canine and the coronoid proeess, the ends of the jaw being usually fraetured or wanting. Only four of the British genera are represented by maxillæ, and only two by both the maxillary and mandibular dentition. In the Amerieau forms, however, several upper and lower jaws have been found by Professor Marsh. Limb bones are rare and when found are still more diffieult to assoeiate. It follows that the only present available basis for classification is the dentition.

We first observe that the Mesozoie Mammalia divide into two large groups. In the first group, A, one of the ineisors is greatly developed at the expense of the others, and of the canine, whieh usually disappears; behind these teeth is a diastema of varying width, followed by premolars whieh are subjeet to great variations in form and number, while the molars bear numerous tubercles. In the seeond group, B, the incisors are small and numerous, the eanine is always present, and well developed; the teeth usually form a continuous series, and the molars bear eusps instead of tubereles. These two divisions suggest those whieh obtain among the modern Marsupials, but are in fact much more sharply defined and widely separated from each other. Professor Flower[2] has shown the difficulties whieh arise from the Diprotodont and Polyprotodont divisions of the reeent Marsupials, upon the lines drawn by Professor Owen, owing to the strong similarity in the structure of the feet observed between families which upon the basis of tooth structure fall into different divisions. Admittiug the marsupial relationship, it is clear that the genera of the first group are closely related to each other and widely separated from the Diprotodonta by their dental strueture which is very dissimilar and indicates that they probably branched off from the stem of the recent marsupials at a remote period, probably the Triassie, (see Appendix).

[1] P. S. This attrition of the inner face of m^1 and m^2 is, however, not observed in the closely related genus *Allodon*, Marsh, but m^4 is placed on a line internal to that in which m^1, m^2 and m^3 lie The relative linear position of the molars in *Bolodon*, as shown in fig. 16, A, is uncertain, they are very much distorted in the specimen and it is possible that m^4 may lie out of line as in the *Allodon* type, (see fig. 10, text).

[2] Article, "Mammalia," Encyclopædia Brittanica, ninth edition, 1883, p. 376.

Therefore, selecting the tubercular character of the molars as a common character, we may adopt for this group, with a modified definition, the Marsupial sub-order *Multituberculata* which has been proposed by Professor Cope.[1] The second group is characterized negatively by its wide separation from the first, rather than by the presence of distinctive characters common to all its members, and for reasons which will be fully stated later, it does not appear to constitute a single well defined division. The first group is much more primitive than the second; it was apparently widely spread in the upper Triassic and extended upwards, while the second group, with the exception of two genera which are very distantly related to the others, appeared in the lower Triassic, and was widely distributed in the upper Jurassic.

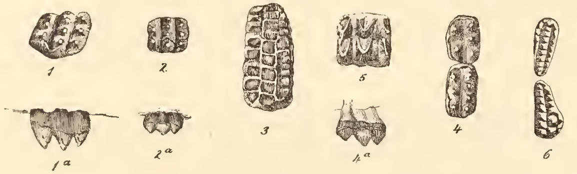

FIGURE 6. The molar tooth forms of the multituberculate marsupials. 1. *Triglyphus*, an upper molar 1a, ditto, in side view, natural size. 2, 2a. *Tritylodon*, an upper molar, m^2, wearing surface and outside view natural size. 3. *Polymastodon*, the second upper molar, natural size. 4. *Bolodon*, the third and fourth upper molars, enlarged about 6 diameters. 5. *Stereognathus*, a lower molar enlarged about 2½ diameters. 6. *Chirox*, the upper molars enlarged 1¾ diameters.

A. FIRST GROUP

SUB-ORDER MULTITUBERCULATA.—Cope.

An extinct sub-order of Marsupials in which the teeth are below the typical number; one incisor on each side is greatly developed; the lower canines are rudimentary or wanting; there is a broad diastema in front of the premolars and the molars are provided with tubercles in two or three rows with longitudinal valleys between them. There is no mylohyoid groove in the mandible.

1. *Plagiaulacidæ*	2. *Bolodontidæ*	3. *Tritylodontidæ*	4. *Polymastodontidæ*
A single lower incisor. Premolars in both jaws developed into flat cutting blades. Lower molars with irregular tubercles; in early forms a vertical; in later forms a fore-and-aft grinding motion between the molars. (Upper molars with three parallel rows of tubercles.)	Two or three upper incisors. Upper premolars tubercular. Upper molars with two regular rows of conical tubercles, adapted to a fore-and-aft grinding motion, separated by longitudinal grooves or valleys.	Two upper incisors. Upper premolars tubercular. Upper molars with three parallel rows of conical tubercles, adapted to a fore-and-aft motion, separated by longitudinal grooves.	A single lower incisor. One simple premolar in the lower jaw, no upper premolars. Two molars in each jaw. Three rows of pavement tubercles on upper molars, two rows on lower molars, adapted to a fore-and-aft motion, without wearing grooves.

[1] "Tertiary Marsupialia," American Naturalist, 1884, p. 681. The order *Allotheria* was proposed by Professor Marsh (Am. Journ. Sc. and Arts, Sept., 1880), to embrace *Plagiaulax* and *Ctenacodon* and other genera, but without the statement of characters sufficient to distinguish it from the *Marsupialia*.

1. PLAGIAULACIDÆ.[1] Marsh.

This family probably embraces the genera *Microlestes*, *Ctenacodon*, *Plagiaulax*, *Ptilodus*, *Neoplagiaulax*, *Meniscoëssus* and perhaps also *Thylacoleo*.

MICROLESTES[2] Plieninger, 1847.

In describing *Plagiaulax*,[3] Dr. Falconer fully recognized the likeness of its molars to those of *Microlestes*. He gave an excellent figure of the molar of *Microlestes antiquus* obtained by Sir Charles Lyell from the original in the Stuttgart Museum, fig. 7, $_1a$, which is much more accurate than the figure copied by Owen, Giebel and others. When these crowns are carefully compared with those of *M. Moorei* (British Museum Collection), fig. 7, $_2$, and with the posterior molar of *P. Minor*, (3, $_3a$) the following resemblances are apparent: the inner margin of the central sub-circular valley is in each case raised into two tubercles (*i*, i^1); these are conjoined in *M. antiquus*, and *M. Moorei*, and separated in *P. minor*, but in each case the antero-internal tubercle is

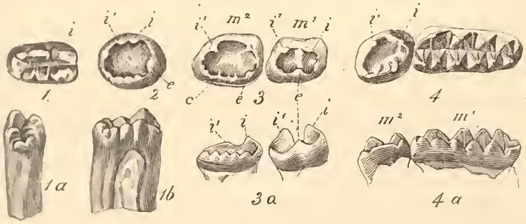

FIGURE 7. The molar tooth forms of the *Plagiaulacidæ*. 1 *Microlestes antiquus* (Stuttgart Collection[4]), a lower molar viewed from above; 1 *a*, posterior face; 1 *b*, external face, greatly enlarged. 2 *c Plagiaulax Moorei*, from above. 3 *Plagiaulax minor*, the lower molars viewed from above, 3 *a*, external face of same enlarged 6½ diameters. 4 *Ptilodus Trovessartianus*, lower molars viewed from above, 4 *a*, external face of same *i* i^1, internal tubercles, *e* e^1, external tubercles. Original.

the most elevated of the two as well as of all the coronal tubercles; the outer margin of the central valley is raised into numerous tubercles, which vary in distinctness but are usually five in number, the antero-external being the most prominent. In *M. Moorei* we observe as an exception, a third small tubercle upon the inner margin. On the other hand, the differences between these molars, are seen in the deeper crenation of the outer margin of *M. antiquus*, and the lateral compression of the crown, which brings the margins nearer together and deepens the valley into a groove more open at the ends than in the *Plagiaulax* molars.

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[1] Proposed by Professor Marsh, Am. Jour. Sc., 1881, p. 511, to embrace *Plagiaulax* and *Ctenacodon*.

[2] "Jahreshefte des Vereins für Vaterländische Naturkunde in Würtemberg," Band II, 1847, p. 164. taf i, figs. 3 and 4.

[3] Quarterly Journal of the Geological Society, August, 1857.

[4] Through the kindness of Dr. E. Fraas, of Stuttgart, I have recently procured this complete set of figures of this type which fully confirm the drawings given by Lyell.

The result of this close comparison is first that, according to our present knowledge, the generic separation of *Plagiaulax* from *Microlestes* (type) is not very wide, and that the English species, *M. Moorei*, so far as known at present,[1] cannot be separated generically from *Plagiaulax*, as it stands nearer this genus than it does to *Microlestes*. Second, we are justified in considering *Microlestes* as the earliest known representative of the *Plagiaulaucidæ*.

PLAGIAULAX, Falconer, 1857.

Type: *P. Becklesii.* *Dentition*, i $\frac{}{1}$ c $\frac{}{0}$ pm. $\frac{}{4 \text{ or } 3}$ m. $\frac{}{2}$ This genus is so well known through Owen's and Falconer's memoirs as to require no detailed description here.[2] The different species mark numerous variations in the number of premolars, in the development of ridges upon their sides, and in the greater or less degree of confluence of the angle with the condyle. The more primitive of the jurassic forms are those in which the premolars are four and faintly ridged, and the angle is entirely distinct from the condyle. The most primitive is *Ctenacodon*, Marsh, which may be considered a distinct genus,[3] if we also subdivide the Purbeck species of *Plagiaulax* into two genera.[4] In this American form the condyle is pedunculate, the angle is effected and inflected and the grooves upon the premolars are so faint as to be scarcely distinguishable. In the specimen of *P. minor*, (Professor Owen's drawing, Pl. IV. fig. 9, is more accurate than that in Falconer's memoirs, Vol. I. Pl. 33), unfortunately, the angular portion of the jaw is wanting; it was probably intermediate between that of *Ctenacodon* and of *P. medius*; there are two or three grooves upon *pms* $_{2\text{-}3}$, while there are about seven grooves on pm_4, extending half-way across the crown. In *P. medius* the premolar grooves are much deeper and more numerous.

The later dental evolution of the *Plagiaulacidæ* is thus foreshadowed in the changes which are observed in progress in the jurassic species, *viz*, the loss of the anterior premolars; the growth and deepening of the ridges upon pm_4; the elongation of

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[1] I judge from the specimen in the British Museum which seems to correspond closely to the figure of the molars in other collections.

[2] I may mention that I observed a faint cingulum upon the second molar of *P. minor*. Waterhouse observed the same (Nat. Hist. of Mamm.,) as cited by Dr. Falconer, Memoirs, p. 426.

[3] Compare Marsh "Jurassic Mammals," April, 1887. p, 332. The characters here assigned to distinguish *Ctenacodon* are: (1) "four premolars instead of three." In Falconer's type *P. Becklesii*, there are but three premolars, but in the closely related *P. medius* (Owen), there is a socket for pm^1, and in *P. minor* pm^1 is well developed. (2) "The summits of the teeth only are notched and the sides smooth." In a close examination of the premolars in *Ctenacodon* very faint grooves can be observed on the sides. (3) "The condyle has a distinct neck, see also *Plagiaulax medius* Falc. "Memoirs," p, 424, and Plate 34, Vol. II. (4). "The outer margin is efflected," see Owen, Mes. Mamm. p, 88. The constant presence of four premolars can be adopted as the generic distinction of *Ctenacodon*, which should naturally embrace *P. medius* and *P. minor*.

[4] Professor Cope makes the *P. minor* of Falconer the type of a new genus, *Plioprion*, characterized by 4 premolars ridged and serrate. Such a definition would also include *P. medius*, Owen, and introduce further confusion, since *P. medius* is very close to *P. Becklesii*.

the molars, accompanied by a multiplication of the tubercles into two thickly studded rows, separated by a groove. In the jurassic species, the molar crowns form a sub-circular basin which shows no signs of fore-and-aft wear, the marginal tubercles being mere crenations; in the later forms, the basin is converted into a groove by the approximation of the sides, the tubercles become distinct, and the groove shows fore-and-

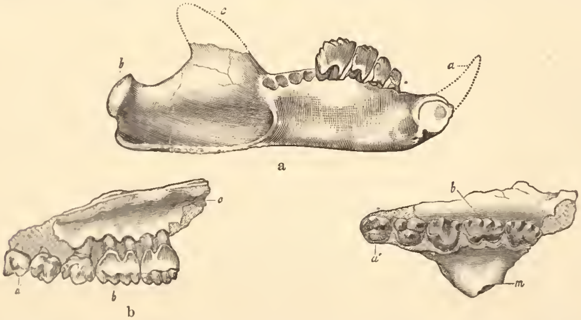


FIGURE 8. a, Left lower jaw of *Ctenacodon serratus*, Marsh, inner view, three times natural size: b, Right upper jaw of *C. potens*, inner view x 4. c, The same seen from below. *a*, First premolar, *b*, fourth premolar as interpreted by Professor Marsh. After Marsh.

aft wear as in the *Bolodon* molars. These stages, already partly described in the valuable memoirs of Cope and Lemoine, may here be presented synoptically:

Ptilodus,[1] Cope.

$i_1\ pm_2\ m_2$

The first and second premolars entirely wanting; the third is rudimentary; the fourth has about 13 oblique grooves. The first molar is narrow and elongate with three internal and five external tubercles. The second molar has two tubercles on the inner row and four upon the outer. There is a well-worn groove between the rows of tubercles.

Neoplagiaulax, Lemoine.

$i_1\ pm_1\ m_2$

The condyle is elevated above the angle and transversely extended. The fourth premolar alone remains and is marked by fourteen deep oblique grooves. The molars are very elongate in m_1, there are six tubercles in the inner, and nine in the outer row. In m_2 there are 3 or 4 in the inner, and 5 in the outer row.

Thylacoleo, Owen.

$i\,\frac{3}{1}\ c\,\frac{1}{0}\ pm\,\frac{3}{1}\ m\,\frac{1}{2}$

The fourth (?) lower premolar only is preserved, with smooth sides and well marked grooves at its base. (Falc. Pal. Mem. Plate 34, fig 9).

N. B. The position of *Thylacoleo* in this series is very doubtful.

Maxillary Dentition of Plagiaulax. The structure of the upper molars has an important bearing upon the relations of *Plagiaulax* and *Bolodon*. Dr. Lemoine[2] in 1883 discovered, among the remains of *Neoplagiaulax*, two molars with a triple row of tubercles, but otherwise so closely resembling those belonging to the mandible, that he conjectured they belonged to the maxillary series. In the maxillary speci-

[1] American Naturalist, 1884, p, 370.
[2] Étude sur le Neoplagiaulax, etc., Pl. VI, fig. 17.

mens of *Ctenacodon* discovered by Professor Marsh, the true molars are unfortunately missing, although the premolar series is complete, (fig. 8, *b*, *c*). The five teeth present increase from before backward. The first and second are of the *Bolodon* type, *i. e.*, with a subcircular crown supporting three conic tubercles; the third is sub-trenchant; the fourth and fifth are trenchant with deeply indented borders. Behind the fifth is a space for two molars. (p, 333 Am. Jur. Mamm.[1])

Is there a family relationship between Bolodon and Plagiaulax? In comparing this series with the corresponding teeth of *Bolodon*, we observe that the *Bolodon* premolars *decrease* rapidly in size from the first to the third; secondly, that the succeeding teeth increase rapidly from the fourth to the seventh; third, that the third tooth behind the diastema in the *Ctenacodon* maxilla is large and trenchant while, in *Bolodon* it is tritubercular and very small; the fourth tooth behind the diastema in *Ctenacodon* is high, trenchant and has an indented upper border, while the similar tooth in *Bolodon* is a lo w crown bearing six conical tubercles. Dr. Lemoine's discovery renders it probable that the upper molars of *Plagiaulax* had three rows of cusps, but in default of positive evidence upon this point, we must compare the *Bolodon* maxillary molars with those of the *Plagiaulax* mandible. They are very widely distinguished from each other (a) by the presence in the former of a strong cingulum which embraces three fourths of the crown; (b), by the double row of distinct conical tubercles with striate sides, arranged in parallel lines, and separated by a well worn median groove. These cannot be mistaken for the crenate margin of the basin-shaped molars of the Jurassic *Plagiaulax;* they belong rather to the *Tritylodon* type of molar with two rows instead of three. I had previously supposed that the edges of lower premolars of the *Plagiaulax* type might fit in these grooves, but this hypothesis is disproved by the above discovery. The two anterior premolars of *C. potens* are, it is true, similar to those of *Bolodon*, but beyond this there is no homology in the maxillary dentition of these genera. The dentition of *Bolodon* suggests a fore-and-aft grinding motion; that of *Plagiaulax* a vertical motion of the mandible. The determination of the dental formulæ in these genera, at the present time, is largely an arbitrary matter. Judging from the natural division of the tooth structure the formula of *Ctenacodon* is $i\frac{1}{1}\ c\frac{0}{0}\ p\frac{5}{4}\ m\frac{2}{2}$, differing from the *Bolodon* formula as given below. The wide separation indicated by these numerous diverse characters overweighs the affinity suggested by the likeness of the two premolars and makes it necessary to place *Bolodon* in a distinct family.

MENISCOESSUS, Cope, 1884.

This genus, from the American Cretaceous, is much larger than the Mesozoic or Eocene *Plagiaulax*. It is represented by a single molar and premolar tooth probably belonging to the maxillary series. The molar tubercles are arranged in three rows,

[1] Professor Marsh places *Allodon* in the *Plagiaulacidæ*.

with four in each, the tubercles of the median row are crescentic, and those of the lateral rows are semi-crescents. The premolars show four notches on one-half of the supposed inner face and three upon the corresponding portion of the outer face; the latter surmount faint vertical grooves while the inner face is smooth. At the bottom of each face is a serrate line representing the cingulum.

FIGURE 9. *Meniscoëssus.*—*a*, Probably an upper molar viewed upon the wearing surface, enlarged two diameters; *b*, probably the inner face of an upper premolar; *c*, outer face of the same; *d*, anterior face of the same. Cope Collection. Original.

The median crescentic and lateral semi-crescentic tubercles of this genus suggest the molar pattern of *Stereognathus*, in which the tubercles are similarly shaped and disposed, but less numerous (Text. fig. 6, 5) and raise a doubt whether the type molar really belongs to the maxillary or mandibular series. The premolar, however, resembles that of the maxilla of *P. potens*, Marsh, more closely than any of the known lower premolars. There is thus little doubt that Professor Cope has correctly placed this genus among the *Plagiaulacidæ*.

2. BOLODONTIDÆ, Osborn[1], 1887.

This family embraces *Bolodon*, the closely allied genus *Allodon* and possibly *Chirox*.

BOLODON, Owen, 1871.

Dentition, i ? $\frac{2}{-}$ c $\frac{0}{-}$ pm $\frac{3}{-}$ m $\frac{4}{-}$. The second upper incisor is large, caniniform, separate from its opposite fellow. The median incisor small or wanting. The second incisor small, with a bicuspid crown, followed by a diastema. Premolars single fanged with faintly grooved sides and tricuspid crowns. The tubercles upon the molars conical, varying from two to four in each row.

ALLODON, Marsh,[2] 1881.

Dentition, i $\frac{3}{-}$ c $\frac{0}{-}$ pm $\frac{3}{-}$ m $\frac{4}{-}$. This genus is separated from the foregoing merely by the presence of the small median incisor which has not as yet been observed in

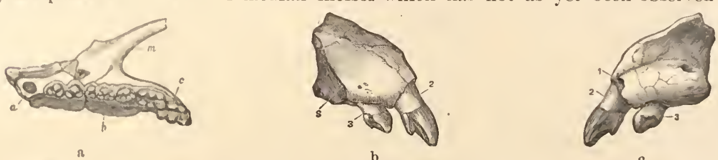


FIGURE 10. Views of the maxilla of *Allodon laticeps*, Marsh; a, seen from below x 4. *Allodon fortis* b, Premaxilla from the outer side, x 3. c, The same from the inner side. *s*, Suture; *a*, Alveolus of lateral incisor or canine. After Marsh.

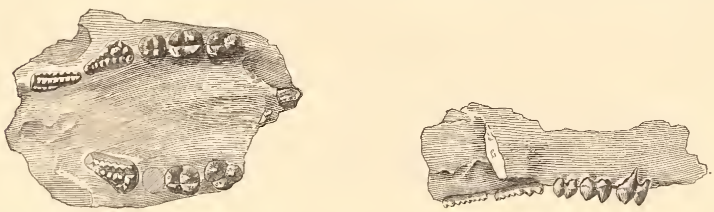
Bolodon. The diastema is narrower and it is possible that a weak canine is present. In all other respects, even to the number of tubercles upon the molars, the genera are alike.

[1] Proc. Phila. Acad., June, 1887. [2] Am. Journ. Sc. and Arts, 1881, p. 511.

Professor Marsh in view of the supposed close relationship of this genus to *Plagiaulax* places but two of the upper teeth in the molar series, giving the post-incisor formula as pm ^{5}, m^2. This can hardly be correct since the three premolars are very sharply separated from the molars by many details of structure such as the number of tubercles, the internal cingulum etc., The first and second molars of *Allodon* have their crowns somewhat flattened on the inner sides but not worn as in *Bolodon*. This further increases the uncertainty as to the character of the lower dentition in this family.

CHIROX, Cope[3], 1883.

Dentition, i? c? pm$\frac{3}{-}$ m$\frac{2}{-}$. The number of premolars is somewhat uncertain. This genus may be provisionally placed in the same family, subject possibly to removal later when its dentition is more fully known. It is represented by a maxilla with three premolars and two premolars *in situ*. The most anterior premolar is the largest, the series decreasing posteriorly; it has but three tubercles while the succeed-



a b

FIGURE 12. *Chirox plicatus*, Cope, one and a half times natural size; *a*, viewed from below, palate with dentition, three premolars and two molars *in situ*; *b*, viewed from the outer side. After Cope.

ing smaller premolars have four. The tubercles are conic, compressed and faintly grooved as in *Bolodon*.. The molars have each two complete and one half-row of tubercles. The first molar has two conic tubercles in the outer half-row, six in the mid-row and seven in the inner row. The tubercles are conic and separated by valleys, not by grooves; the inner face of the crown is smooth The second molar has the half-row on the inner side; the mid and outer rows, have eight tubercles each, separated by grooves apparently indicating fore-and-aft wear.

Several interesting resemblances will be noted between this and the *Bolodon* series. *Chirox* seems to be transitional in the structure of its molars, between the two and three row type, the additional half-row appearing to arise from the cingulum, but the premolars both in form and number are very similar to those of *Bolodon*, with

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[3] Proc. Amer. Phil. Society, p. 321, 1883. Also, Amer. Naturalist, June, 1887, p. 566. Professor Cope places this in a new family, the *Chirogidæ*, but I think it may for the present be retained in the *Bolodontidæ*.

the exception of the additional tubercle upon the two posterior. In both genera the premolars decrease in size antero-posteriorly. The first molar of *Chirox* has unworn valleys between the tubercles and a smooth inner face as in m^1 and m^2 of *Bolodon*; while the second molar resembles m^3 and m^4 of *Bolodon* in the signs of antero-posterior wear between the tubercles. For these reasons I am inclined to regard *Chirox* as a successor of *Bolodon*, or as having a relation somewhat similar to that which may have obtained between *Polymastodon* and *Tritylodon*.

3. TRITYLODONTIDÆ, Cope [1], 1884.

TRITYLODON, Owen [2], 1884.

Dentition, i $\frac{2}{-}$ c $\frac{0}{-}$ pm and m $\frac{6}{-}$. One large median vertical incisor is followed by a small incisor and this by a wide diastema. Behind this are two teeth with broken crowns, the foremost or both of which may represent premolars. Behind these are four quadrate molars with three parallel rows of conical tubercles, separated by well worn grooves. In m^3 to m^5 inclusive there are three tubercles in the inner row, four in the middle row and two in the outer row. In the sixth molar the tubercles are less numerous. The face is elongate. The frontals do not join the premaxillaries. The parietals diverge anteriorly into a wide depresson.[2] The lachrymals are well developed upon the face, and the foramen is intra-orbital. The anterior nares are terminal. The posterior nares are between the fifth and sixth molars.

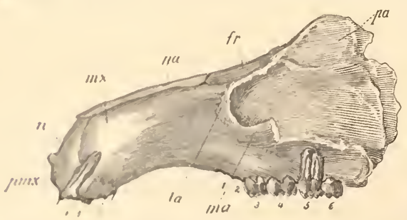

FIGURE 13. *Tritylodon longævus*, anterior portion of the skull viewed upon the left face, two thirds natural size. After Owen.

TRIGLYPHUS, Fraas [3], 1868.

This genus is represented by a single molar which closely resembles in the number and disposition of its tubercles the molars 3—5 of *Tritylodon*, as pointed out by Neumayr [4]. When these teeth are closely compared (fig. 6, $_1$ and $_2$), they will probably prove to belong to the same genus, in which case Prof. Fraas' genus has the priority.

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[1] American Naturalist, loc., cit.

[2] Quart. Journ. of the Geological Society. Dr. George Baur kindly investigated this skull at my request and reports that there is no trace of a foramen here.

[3] Discovered in the Rhætic Beds near Stuttgart and described by Prof. Fraas in his work, "Vor der Sündfluth," page 215.

[4] Neues Jahrbuch, f. Min., Geol., und Pal., 1884., p. 279.

The accompanying figures represent two views of the crown of a small tooth from the supposed Rhaetic Bone Bed near Hohenheim, not far from Stuttgart. It has been preserved for many years in the Mineralogical Cabinet of the Akademie Hohenheim, and was forwarded to the writer by Prof. Dr. F. Nies, through the kindness of Dr. Baur. It has not been heretofore described. It consists of a low quadrate crown supporting four smooth, conic tubercles at the corners, which are very slightly worn; the fangs are wanting; the history of the specimen is somewhat uncertain. If it is actually from the Rhaetic Beds, it probably represents a premolar of *Triglyphus* or one of the allied *Tritylodonts.*

Fig. 14. Premolar of *Triglyphus* (?) *a*, Upper view; *b*, side view. $\frac{5}{3}$ natural size.

POLYMASTODONTIDÆ, Cope, 1884.

This embraces the single genus *Polymastodon* (Cope) which has several known species. The dentition is $i\,\frac{1}{1}\ c\,\frac{0}{0}\ pm\,\frac{0}{1}\ m\,\frac{2}{2}$. The family character as stated by Professor Cope, is that the fourth premolars are more simple than the first true molars. This is a rather uncertain distinction from *Tritylodon* in which the crowns of the premolars are not known. The dentition is much reduced. As there are no worn grooves between the rows of tubercles, the upper tubercles simply oppose the lower, without alternating with them. No other family character is at present to be found, although it seems as clear that *Polymastodon* and *Tritylodon* belong to separate families as it is that they belong to the same sub-order.

The incisors resemble those of the *Plagiaulacidæ.* The molars have three rows of numerous tubercles in the maxilla, and two rows in the mandible; these tubercles are flattened into a tesselated pattern, lacking the longitudinal grooves. Various portions of the skeleton are described by Prof. Cope.

INCERTÆ SEDIS

STEREOGNATHUS, Charlesworth[1], 1854.

The lower molars support six cusps arranged in three antero-posterior rows of two cusps each. From the tip of each cusp of the middle pair two low ridges diverge, forming a V, opening forwards. The lateral pair of cusps have similar ridges extending from the median side of the cusp only, towards the centre of the crown (fig. $6,_5$).

It is doubtful whether *Stereognathus* belongs to this sub-order, or to the following group. It cannot be placed in any of the foregoing families, since the lower molars have three rows of cusps instead of two. At the same time it is even more remote from any of the genera of the second group. The nearest likeness to its molar pattern is seen in the *meniscoëssus* superior molar.

[1] Report Brit. Assoc., 1854, p. 80; also Owen, Quart. Jour. Geol. Soc., 1857, p. 1.

B. SECOND GROUP.

TRIASSIC PERIOD.

While the American jurassic fauna is closely related to the British, the American triassic fauna is widely separate from both, so far as we can judge from the scanty material which has been obtained from the North Carolina Beds. In the jurassic forms of both countries the crowns of the molars are well distinguished from the fangs, and the latter are distinctly paired or multiple, except in cases where they are undergoing a secondary union (*Kurtodon*). In the two triassic genera known at present, the crowns are continuous with the fangs, and the only evidence that the fang is divided is a shallow median depression at the base which opens downwards. A similar division of the base of the crown has been observed by Professor Cope, in *Dimetrodon*, one of the *Theromorph* reptiles of the Permian. This character is, therefore, of great interest and importance, and necessitates the ordinal separation of these genera from those of the Jurassic period.

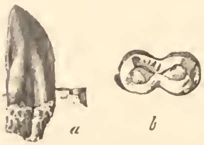

Fig. 8,— *a*. Inner aspect of a lower tooth of *Dimetrodon*, showing the grooved condition of the fang. *b*, Section of another tooth showing the division of the pulp cavity. Cope collection. Original.

ORDER PROTODONTA.[1]—Osborn.

Primitive heterodont mammals in which the fangs of the molars and premolars were unpaired and not well distinguished from the crowns, the incipient division of the fang being represented by a lateral groove on the base of the crown.

DROMOTHERIIDÆ, Gill, 1874.

This family was proposed by Gill[2] and adopted by Marsh[3], without definition, to include *Dromotherium*. It may now be defined to embrace also *Microconodon*, as follows: *A wide diastema behind the canine. Premolars styloid and without a distinct heel. Molars with the main cusp and the lateral cusps in the same fore and aft line.*

DROMOTHERIUM, Emmons,[4] 1857.

Dentition—$i_{3}\, c_{1}\, pm_{3}\, m_{7}$. The incisors are caniniform, recurved and separate. The canine is large and recurved, followed by a wide diastema. The premolars are styloid and semi-procumbent with ungrooved fangs. The last premolar crown has a deep posterior groove. The molars have imperfectly divided fangs. There is a lofty main cusp and irregularly disposed anterior and posterior cusps, sometimes multiple,

[1] "The Triassic Mammals, Dromotherium and Microconodon," Proc. Am. Phil. Society, April, 1887. By the Author.

[2] "Arrangement of the Families of Mammals, &c.," Smithson. Misc. Coll., 1874, p. 27.

[3] Am. Journ. Sc. and Arts, April, 1887, p. 344.

[4] American Geology, Part VI, pp. 93 and 94. 1857.

upon the anterior and posterior slopes. The molars have perhaps a faint posterior, but no internal cingulum. The mandible is very stout with a lofty coronoid process. The condyle is probably midway between the angle and coronoid. There is a deep mylohyoid groove terminating beneath the molars. The symphysial surface is indistinct.

MICROCONODON, Osborn,[1] 1886.

Dentition.—I ? c ? $pm_{\overline{3}}$, $m_{\overline{7}}$, or $pm_{\overline{4}}$, $m_{\overline{6}}$. There is a wide diastema behind the canine. The premolars are erect and subconical, with a faint posterior cingulum, and the third possesses a slight lateral groove in the fang. The molars have a shallow grooved division of the fang. There is a large median cusp and regular anterior and posterior cusps, in no case multiple. There is a distinct cingulum posteriorly, which may represent the extension of an internal cingulum. The mandible is slender, the coronoid low; the condyle is probably low, and the angle is represented by a curvature of the lower border as in *Peramus*.

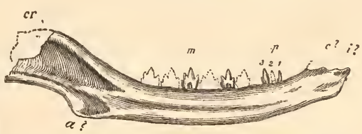

FIGURE A. *Microconodon tenuirostris*, outer face of the right mandibular ramus; four times natural size. Dotted contours of molars conjectural. Coll. Phila. Academy. Original.

JURASSIC PERIOD.

The jurassic genera of the Second Group, like the triassic, possess a mylohyoid groove upon the inner surface of the mandibular ramus. They differ from the known triassic genera, first, in the complete division of the molar fangs; second, the premolars are not separated from the canine by a diastema, except in cases where they have evidently suffered numerical reduction. They are generally further distinguished by the following characters: The incisors vary from four to three in number. The canines are invariably present, usually well developed and frequently bifanged. With a few exceptions there are four premolars, well distinguished in pattern from the molars; in other words the dentition is distinctly heterodont.[2] The molars vary from four to eight, generally exceeding the former figure, and present a variety of patterns of the cusped, but not of the tubercular order. These features

[1] "Observations upon the Upper Triassic Mammals *Dromotherium* and *Microconodon*." Proc. Phila. Acad. Nat. Sc., 1886, p. 359.

[2] *Phascolotherium* forms an apparent but not real exception, since the premolars have probably disappeared. In *Diplocynodon* (Marsh, loc. cit. Plate X), the premolars when viewed upon the inner surface are very distinct from the molars, although the outer aspect of the series is uniform. Professor Marsh, however, gives the imperfect differentiation of the premolars and molars as one of the characters of the "Pantotheria," an order proposed for the reception of this group.

distinguish the mammals of this period, so far as known, very clearly from the *Multituberculata* and *Protodonta*.

In this, as in the former divisions, the molar pattern forms an advantageous starting point for classification. The entire dentition is in fact distinctly, although not highly, specialized; in carefully studying the details of the numerous members of this group we invariably find a certain form of premolar, canine and incisor accompanying a certain molar pattern and an equally fixed relation existing between the dentition and the characters of the mandible. In some cases where the molars are apparently rather diverse, the structure of the remaining teeth and of the mandible brings us back to the conclusion that there is some affiliation. As the genera fall into smaller groups we at once observe that these groups show a more or less clearly marked specialization for a certain kind of diet, which is usually manifested most clearly in one genus, which we may therefore speak of as typical of the group. The allied genera diverge more or less widely from this type, which, it must be understood, is not selected as the most primitive or the most central but as showing the most clearly defined functional adaptation. While some genera are thus functionally *typical* others are *transitional*, that is, they show a divergence from the central type towards a different kind of adaptation. Still other genera are *isolated ;* they do not approach other known types but stand apart by themselves, either because few specimens have been found and we are less familiar with their structure, or their molar pattern does not conform with that of any other known genus, or represent a distinct type. Our first object then is, where possible, to group the genera into families; secondly, to unite these families into what we may call sub-groups, indicating their general adaptation to a certain diet. The sub-groups naturally have less permanent taxonomic value than the families, and still less than the genera. The families are thus grouped where they seem to show evidence of being in *early stages of differentiation along certain lines of functional adaptation.* These lines are not sharply defined, but by a comparison of the typical forms of each of these sub-groups with the most nearly allied recent genera we may divide them into carnivorous, omnivorous, herbivorous and insectivorous series, as indicating, in most cases, an initial rather than an advanced stage of specialization.

The genera are now, for the most part, clearly distinguished from each other, but the *Stylacodontidæ* is the only fully defined family, in which numerous genera, with unmistakeable relations to each other and the dentition of both jaws known, are included. The other families are naturally subject to change their boundaries when we come into possession of more material. It is probable, for example, that the *Triconodontidæ* will embrace a larger number of genera.

In connection with the latter family, the question arises, how far the number of molar teeth should enter into the problem of classification. As a case in point, the molars of *Amphilestes*, *Phascolotherium* and *Triconodon* clearly belong to the same type, but the formulæ are respectively pm_4, m_7, pm_5, m_7 and pm_4, m_4. The alternatives are to place them in three families or in one. I have finally adopted the latter[1] upon grounds which are more fully stated later.

In describing the teeth a distinction has been made between a "heel" or sloping extension at the base of the crown, a "basal cusp" and a "cingulum cusp," which is simply a prominent portion of the cingulum. These distinctions also enter into the classification frequently, especially in connection with the premolars.

The chief molar types of this group are shown in the accompanying figure.

FIGURE 10. The principal molar tooth forms of the Mesozoic Mammals of the Second Group. The anterior face of the molars throughout is to the left, and the posterior face to the right. A, *Dromotherium*, the second lower molar, inner face × 7. B, *Microconodon*, the fourth lower molar, outer face × 7. 1, *Amphilestes*, the second lower molar, inner face. 3, *Phascolotherium*, the fifth lower molar, inner face 4, *Triconodon*, the second lower molar, inner face. 6, *Peramus*, the fourth lower molar, outer face. 7, *Spalacotherium*, the third lower molar, inner face; *a*, outer face. 8, *Peralestes*, third upper molar, inner face. 9, *Peraspalax*, third lower molar, inner face. 10, *Leptocladus*, third lower molar, outer face. 11, *Phascolestes*, third lower molar, inner face. 13, *Achyrodon*, fourth lower molar, outer face. 12, *Dryolestes*, lower molar, inner face; *a*, outer face; *b*, wearing surface. 15, *Kurtodon*, upper molar; *a*, wearing surface. Original.

In the first type there are three cusps in the same fore-and-aft line (figs. 1, 3, 4, 11, 13). In the second the cusps are placed upon opposite sides of the crown and separated by a median valley (figs. 8 and 9). In the third the cusps are placed upon opposite sides of the crown, but connected by transverse ridges (figs. 12, 12*a* and *b*). In the fourth the crown is columnar, there are no cusps, and the fangs are placed transversely (figs. 15 and 15*a*). Transitional types are seen in figs. 6 and 7. Fig. 10 represents an isolated type. The next figure shows the form of the premolars which accompany these types, the numbers corresponding to the above. A compari-

[1] In the preliminary abstract of this paper *Amphilestes* was embraced in the *Triconodontidæ*, and *Phascolotherium* and *Spalacotherium* made the types of other families.

son of these teeth with the corresponding mandibles, gives us an outline of the correlation which is the basis of classification.

A B 15 4 9 7 11 12 13

FIGURE 11. The premolar tooth forms of the mammals of the Second Group. The premolar represented is invariably the most posterior of the series; the anterior face is to the left. The reference numbers are the same as those given above for the molars, and correspond to those upon Plates VIII and IX. Nos. A, 4, 9, 11, 12 are seen upon the inner surface, the remainder upon the outer surface. Original.

Incisors.	*Canines.*	*Premolars.*	*Molars.*	*Mandible.*	*Typical genus*
1. Erect.	Large and erect.	With distinct basal cusps.	With three stout cusps and cingulum.	Stout, with a broad coronoid and low condyle.	*Triconodon.* (4)
2. Erect.	Large and erect.	With distinct basal cusps.	With opposed cusps. Unconnected.	Stout.	*Peralestes.* (*Peraspalax.*) (9)
3. Unknown.	Large.[1]	Small, or transitional to molars.	With no cusps. Columnar. No cingulum.	Unknown.	*Kurtodon.* (15)
4. Procumbent.	Small and semiprocumbent.	With a "heel" or cingulum cusps.	With three slender cusps. No cingulum.	Slender, with a narrow coronoid and high condyle.	*Amblotherium.* (11)
5. Procumbent.	Small and semiprocumbent.	With a "heel"	With opposed cusps. Connected.	Slender, with a narrow coronoid and high condyle.	*Stylacodon.* (12)

These genera are typical not only of families but in a less degree of Sub-Groups. As remarked before, the same degree of functional specialization for insectivorous, carnivorous or other diet is not by any means observed in all the allied genera, yet we may broadly attribute this specialization to the entire sub-group as a general characteristic. The sub-groups were the Insectivora, Carnivora, etc., of the mesozoic period; not in the recent sense of these terms, but in relation to their feeding habits.

SUB-ORDER PRODIDELPHIA.—Haeckel.[2]

Primitive Marsupials, generally distinguished from the recent forms by the frequent presence of four premolars and numerous molars. Molars with distinct multiple fangs; molar crowns not fully tritubercular or tubercular-sectorial.

CARNIVOROUS AND OMNIVOROUS SUB-GROUP.—The mammals which are included in this sub-group have many points of mutual resemblance, although upon the first examination they appear to differ widely. They sub-divide into two series :—

(1) The first, embracing the family *Triconodontidæ*, includes all the largest genera and some of intermediate size, and is distinguished by the primitively sectorial

[1] This tooth is possibly an incisor.

[2] Proposed without definition in the "History of Creation," and provisionally defined and adopted here.

character of the molars. This is the CARNIVOROUS series, and may be distinguished as follows: the molars have three stout, erect cusps in the same fore-and-aft line, or with the lateral pair rotated inwards, without an internal heel but showing an internal cingulum. The premolars, when present, have prominent "cingulum" or "basal" cusps. The canines are erect. The incisors are semi-procumbent to erect. The mandible is usually stout, with a broad coronoid process, and in two cases a transversely extended condyle on or below the molar level and often on the plane of the angle. The most highly specialized genus is *Triconodon*, in which the incisors, canines and premolars are well adapted to a carnivorous diet; the molar cusps are sub-trenchant, the upper being worn sharp by the lower. (Plate VIII, fig. 4). The closest modern ally is *Thylacinus*.

(2) The second, or OMNIVOROUS series, embraces a number of families which are closely inter-related both as regards their dentition and probable form of diet. The molars are characterized by a more or less complete opposition of cusps upon the crown, *i. e.*, the cusps are placed transversely, but do not show the sectorial disposition. In the typical forms, such as *Peralestes*, the upper and lower molars oppose each other somewhat as in *Didelphys*, but not with cutting edges. The internal cingulum, invariably present in the first sub-group, is here replaced in the lower molars by a more or less prominent series of cusps. The posterior basal cusps of the premolars, if present, are somewhat less prominent than in the first group; anterior basal cusps are always wanting. The canines are stout, erect and often recurved. The condyle is rounded and upon the molar level. The mandible is moderately stout and rounded at the symphysis, indicating an erect position of the incisors. The coronoid is narrower than in the first group. The angle is always separate and well defined.

1. CARNIVOROUS SERIES.

1. TRICONODONTIDÆ,[1] Marsh, 1887.

The *Triconodontidæ* may be defined as follows: *Upper and lower molars with three stout, erect cusps and strong internal cingulum, not opposed. Opposition of upper and lower molars sub-trenchant. Canines stout and erect, often bifanged. Incisors semi-procumbent or erect. Premolars with prominent basal cusps. Condyle low, articular face sometimes broad. Coronoid process broad. Angle sometimes inflected.*

This family embraces numerous genera which are apparently upon divergent lines of descent, but are not sufficiently distinct to be placed in three separate families, so that we may conveniently, and with more probability of rightly expressing their relations, divide them into three sub-families. *Amphilestes*, from the lower Jurassic, is the most central genus, as it has the full complement of teeth and the

[1] "Am. Journ. Sc.," April, p. 341.

molars are of an intermediate form. *Amphitylus*, from the same strata, stands near it (although not very fully known and presenting some features exeeptional in this sub-group); while *Triconodon*, from the Upper Jurassie, is much modernized. *Phascolotherium*, of the seeond sub-family, from the Lower Jurassic, apparently laeks premolariform teeth, but is linked with the other *Triconodontidæ* by *Tinodon* (Upper Jurassic) which has premolars. The molars in each of the latter genera are intermediate between those of *Amphilestes* and *Spalacotherium*, which, in turn, is the type of the third sub-family. The primitive genera have four incisors, but the lateral incisors, i_4, disappear in their successors.

a. *AMPHILESTINÆ.*[1]

Molar cusps in same fore-and-aft line; little or no reduetion of the premolar series; angle distinct.

AMPHILESTES, Owen,[2] 1871.

Dentition—i_4, c_1, pm_4, m_7. The posterior basal eusps of the premolars, if present, are not fully distinet from the cingulum. The anterior basal cusps belong to the cingulum. The middle cusps of the molars are much more prominent than the anterior and posterior. The molars are separated, the internal eingulum projeeting beyond the anterior and posterior slopes of the crown. The condyle is distinet from the angle and on the molar level.

AMPHITYLUS, Osborn,[3] 1887.

FIGURE 10b. *Amphitylus Oweni*, after Owen (*A. Prevostii*), two and one eighth times natural size, from the Buckland collection.

Dentition—i_4, c_1, pm_4, m_7. The premolars[4] resemble those in the last genus. The molars have three blunt, eompressed cusps, and are compactly placed. The eingulum is less prominent and does not embrace the anterior and posterior slopes of the erown. The condyle is lofty and peduneulate.

TRICONODON, Owen,[4] 1860.

Syn. *Triacanthodon*, Owen,[5] 1871.

Dentition—i ? $\frac{3}{3}$, c $\frac{1}{1}$, pm $\frac{4}{4}$, m $\frac{4}{4}$ or $\frac{3}{3}$. As shown upon page 196 of this memoir, the fourth molar comes into plaee only in old individuals or is developed as a speeifie character. In young individuals the fourth premolar, d_4, is molariform and is shed early. The premolars have prominent posterior and sometimes anterior basal cusps. The molars have three sub-equal trenehant eusps. The canines are stout and re-

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[1] Sub. fam. nov.

[2] "Mesozoic Mammalia," p. 16.

[3] Type *Amphitherium Prevostii*, Owen. (See this memoir, p. 193.) Proc. Phila. Acad., June, 1887. This generic description is based merely upon the data and figures furnished by Owen.

[4] Encyclop. Brit., Vol. 17, 1859. Art. Palæontology (*fide* Owen).

[5] "Mesozoic Mammalia," p. 72.

curved, sometimes bifanged. The incisors are compactly placed and recurved. There is no diastema. The angle and condyle are upon the same level.

PRIACODON, Marsh,[1] 1887.

Syn. *Tinodon ferox*, Marsh.[2]

Dentition—i $\frac{-}{?}$, c$\frac{-}{1}$, pm$\frac{-}{3}$, m$\frac{-}{4}$. This formula is somewhat uncertain, as the type may be immature There is a diastema behind the canine, followed by three premolariform teeth. The fourth tooth is molariform but may represent a milk molar, in which case this genus is a synonym of *Triconodon*. The dentition, as given by Marsh, is pm$\frac{-}{3}$, m$\frac{-}{4}$, but may prove to be pm$\frac{-}{3}$, d$\frac{-}{4}$ = $\frac{-}{4}$, m$\frac{-}{1}$. The first molar lacks the full sized cusps which characterize m_1 in the adult *Triconodon*, and resembles the milk molar of *T. serrula*, Owen.

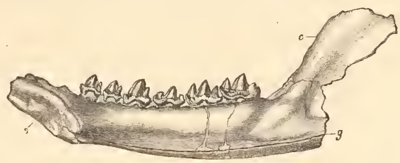

FIGURE 10a. Right lower jaw of *Priacodon* (*Triconodon*) *ferox*, inner view; three times natural size. After Marsh.

b. PHASCOLOTHERIINÆ.[3]

Lateral molar cusps upon inner slopes of central cusps. Extensive reduction of premolar series, or, premolars and molars alike. Angle confluent with lower border of mandible.

PHASCOLOTHERIUM, Owen,[4] 1839.

Dentition—i $\frac{-}{4}$, c $\frac{-}{1}$, pm $\frac{-}{0}$, m $\frac{-}{7}$. The incisors are styloid and separate. There is a wide diastema behind the canine. Premolariform teeth are wanting. The molars have a stout central cusp bearing the smaller anterior and posterior cusps somewhat upon its inner face. The angle is represented by the inflected lower border.

TINODON, Marsh,[5] 1879.

This genus is distinguished from *Phascolotherium* by the presence of eight or more teeth behind the canine (*fide* Marsh), and by the inward rotation of the lateral cusps. So far as known at present it is closely similar in all other respects.

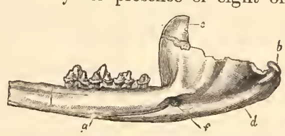

FIGURE Right lower jaw of *Tinodon bellus*, inner view; three times natural size. After Marsh.

c. SPALACOTHERIINÆ.

Lateral cusps of lower molars strongly rotated inwards. Premolars full or not greatly reduced in number, and unlike molars. Angle and condyle confluent with lower border of mandible.

[1] Loc. cit., p. 341.

[2] "Am. Journ. Sc.," 1880, p. 236.

[3] Sub. fam. nova.

[4] "Geological Transactions," second series, Vol. 6, p. 58.

[5] "Am. Journ. Sc.," Vol. 18, p. 216.

SPALACOTHERIUM, Owen,[1] 1854.

Dentition—i $\frac{-}{?3}$, c $\frac{-}{1}$, pm $\frac{-}{4}$, m $\frac{-}{6}$. The incisors are compactly placed, pointed and recurved. The canine is rather slender, erect and recurved. The premolars have anterior "cingulum cusps" and prominent posterior "basal cusps." The main cusp of the molars is continuous upon its outer face with the internally placed anterior and posterior cusps. The internal cingulum forms a broad shelf. The angle and condyle are both elevated.

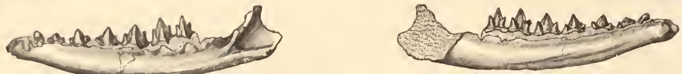

FIGURE 21. Left lower jaw of *Menacodon rarus*, outer and inner view; three times natural size. After Marsh.

MENACODON, Marsh,[2] 1887.

Dentition—i $\frac{-}{?}$, c $\frac{-}{1}$, pm $\frac{-}{3}$, m $\frac{-}{4}$. The canine is small and directed well forward. The premolars resemble those of *Spalacotherium*. The anterior and posterior cusps of the molars are not so fully rotated inwards as in the foregoing genus and are more separate upon the outer face. The median cusp is less lofty. The mylohyoid groove is less distinct.

NOTE.—*Amphitylus* is placed in the *Triconodontidæ* upon the basis of its molar structure, although the position of its condyle is exceptional and considered alone would remove it from this group. The position of the condyle in *Amphilestes* is inferred from Owen's description and earlier figures (see Plate VIII, fig. 1). It will be observed that *Tinodon*, in its molar structure and the shape of the jaw, affords such a clear transition between the *Amphilestinæ* and *Spalacotheriinæ*, that there is no present ground for a wider separation of these genera than that here adopted, although such ground may be subsequently discovered.[3] If the number of the premolars and molars be allowed great weight in classification it is clear that the above genera must be divided into four families.

2. OMNIVOROUS SERIES.

AMPHITHERIIDÆ, Owen,[4] 1846.

Upper molars with one main external cusp and two lateral cusps, and one main

[1] "Quart. Jour. Geol. Soc.," London, vol. 10, p. 426.

[2] "Am. Jour. Sc. and Arts," April, p. 340. I follow Professor Marsh's description, although I think it not improbable that four premolars and five molars will be found in a more complete specimen.

[3] It is so easy to overlook the distinctions between the premolar and molar patterns in these minute jaws (see Marsh, *Tinodon*, p. 340, "Am. Jur. Mamm."), that until the post-canine dentition of *Tinodon* is fully described and figured I may be pardoned for questioning the statement that "the premolars of this genus have the same general form as the molars." This statement is also made in regard to *Menacodon*, in which the premolars are very distinct in pattern from the molars (p. 340).

[4] "British Fossil Mammals and Birds," 1846, p. 29.

internal cone with a small posterior heel (Diplocynodon).[1] *Lower molars with two lofty external cusps and a posterior heel, connected with a broad crenate internal cingulum. Opposition of upper and lower molars not trenchant. Premolars with distinct "cingulum" and "basal" cusps. Canine bifanged. Incisors erect. Condyle low, rounded and upon molar level. Coronoid process elevated, but not very broad. Angle short, anteriorly placed, not inflected, always distinct from lower border and from condyle. The molars have two fangs placed in line.*[2]

Although this family belongs in this sub-group as now defined, its members present a more primitive dentition than the following family. The molar pattern is a good example of the "transitional" type, in which the internal cingulum is giving rise to a complete row of internal cusps and to the "opposition" pattern. The writer has found it very difficult to assign *Amphitherium*, from the English lower Jurassic, its proper position. Its wide distinction from *Amphilestes*, with which it was at first placed by Professor Owen, is shown by the absence of the third cusp; it is thus upon an entirely different line of descent. As observed by Professor Marsh, the molar pattern of *Diplocynodon*, and the allied jurassic genera, distantly approaches that of *Amphitherium*; in both genera the molar is bicuspid with a posterior heel which extends upon the postero-internal face of the crown into a broad crenate cingulum. The *Amphitherium* molar then differs from the *Diplocynodon* molar in the greater development of the anterior cusp—a difference of degree only. The mandibular characters of these genera are very similar. This anterior or second cusp is wanting in the molars of *Peralestes*; the *Amphitheriidæ* may thus be sharply distinguished from the *Triconodontidæ*, and less widely from the *Peralestidæ* as above.

AMPHITHERIUM, De Blainville,[3] 1838.

Dentition—? i $\frac{-}{?}$, c $\frac{-}{1}$, pm $\frac{-}{4}$, m $\frac{-}{6}$. This formula is somewhat uncertain, being derived from a study of Prevost's and Owen's drawings, and from the description given by the latter. The premolars have posterior "basal" and anterior "cingulum" cusps. The molars have two main cusps and a posterior heel, and an internal cingulum bearing a prominent cingulum cusp.

DIPLOCYNODON, Marsh,[4] 1880.

Dentition—i $\frac{-}{3}$, c $\frac{1}{1}$, pm $\frac{-}{4}$, m $\frac{-}{8}$. The jaw is elongate and gently curved below. The mylohyoid groove is parallel with the lower border of the ramus. The coronoid is large and elevated. The condyle is nearly upon a line with the teeth. The

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[1] Marsh, "Am. Jur. Mamm.," p. 338, 1887. The writer has not examined the upper molars of this genus.

[2] This family is equivalent to the *Diplocynodontidæ*, Marsh, 1887.

[3] Comptes Rendus, Aug. 20th. "Doutes sur le prétendu Didelphe fossile de Stonesfield." Unfortunately I have been unable to procure good figures of the internal aspect of the teeth of this genus.

[4] "Am. Jour. Sc. and Arts," 1880, p. 235. *Diplocynodon* is preoccupied by Pomel. (See Appendix).

antero-posterior faces of the upper and lower molars are deeply excavated and grooved. The second premolar is smaller than the first. The premolars have distinct external cingula.

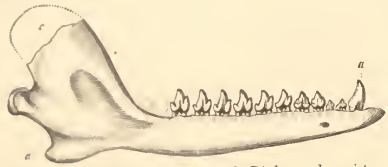

FIGURE 22. Right lower jaw of *Diplocynodon victor*, outer view, twice natural size.

DOCODON, Marsh,[1] 1881.

Dentition.—i $\frac{-}{3}$, c $\frac{-}{1}$, pm $\frac{-}{4}$, m $\frac{-}{7}$. This genus is closely similar to the preceding, but lacks the eighth molar.

ENNEODON, Marsh,[2] 1887.

Dentition—i $\frac{-}{2}$, c $\frac{-}{1}$, pm $\frac{-}{3}$, m $\frac{-}{6}$. The canine is very large. The surface of the premolars is grooved or striate. The antero-external cusps of the molars are less distinct than in *Diplocynodon.* The second premolar is apparently missing.

PERAMUS, Owen,[3] 1871.

Dentition—i $\frac{-}{?}$, c $\frac{-}{1}$, pm and m $\frac{-}{9}$. This genus may be provisionally embraced in the *Amphitheriidæ* as above defined. In *Enneodon* we observe that the antero-external cusps of the molars are slightly rotated inwards upon the inner face of the crown, as in *Peramus* (see Marsh, "Am. Jur. Mamm.," Plate X, fig. 2, m_3). The articular portion of the jaw in *Peramus* is essentially similar to that in *Diplocynodon*, although the coronoid is slightly narrower. The condyle has the same level. The angle in both is short and obtuse.

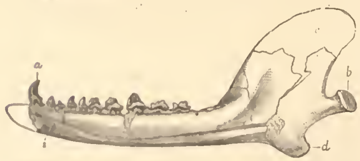

FIGURE 23.—Right lower jaw of *Docodon striatus*; inner view, twice natural size. After Marsh.

The formula assigned to *Peramus*, $pm_{\bar{6}}, m_{\bar{3}}$, upon page 202 of this memoir, was in view of the fact that only the three posterior molars possess antero-external cusps. But the presence of six premolars is so exceptional a feature that it is probable that when seen upon the internal face (the outer face only is known at present) the formula would resolve itself into $pm_{\bar{4}}$ $m_{\overline{5 \text{ or } 6}}$. As thus divided, the premolars appear to lack posterior basal cusps, and have no external cingulum; while upon the above hypothetical formula the anterior molars have no antero-external cusps. The main molar cusps are erect, and there is an anterior

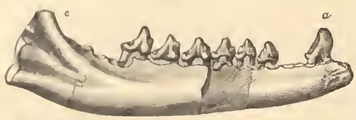

FIGURE 24.—Right lower jaw of *Enneodon crassus*; outer view, three times natural size. After Marsh.

[1] "Am. Jour. Sc. and Arts," 1881, p. 512.
[2] "Am. Jur. Mamm.," p. 339.
[3] "Mesozoic Mammalia," p. 41.

basal cusp, not observed in *Diplocynodon*. These features render the position of *Peramus* in this family somewhat doubtful.

PERALESTIDÆ, Osborn,[1] 1887.

Upper molars with lofty internal and several low external cusps transversely opposed, i. e., separated by a longitudinal valley (*Peralestes*). *Lower molars with a single lofty external and several internal cusps* (*Peraspalax* and *Paurodon*). *Opposition of upper and lower molars not trenchant. Molar fangs, two in line. Premolars with basal cusps, variable, usually strong. ? Canines single fanged.*

PERALESTES, Owen,[2] 1871.

Dentition—$i\frac{-}{}$, $c\frac{1}{-}$, $pm\frac{4\text{ or }5}{}$, $m\frac{6}{-}$. The fourth premolar has an elevated external cingulum and a lofty crown rising above the molar level. There are two internal cusps upon the molars; the antero-internal is the main one and is slightly retroverted; the postero-internal cusp is much lower. The outer side of the crown is a ridge supporting an antero-external cusp and two or three tubercles behind this.

PERASPALAX, Owen,[3] 1871.

(Syn. of *Peralestes*, ?) *Dentition*—$i\frac{-}{?}$, $c\frac{-}{1}$, $pm\frac{-}{4}$, $m\frac{-}{7}$. The premolars have elevated conical crowns and a strong internal cingulum, rising to the anterior cingulum cusps and to the posterior basal cusps. The molars have a single external antero-verted cusp. The internal cusps consist of a high median and low anterior and posterior cusps at the ends of the crown.

PAURODON, Marsh,[4] 1887.

Dentition—$i\frac{-}{?}$, $c\frac{-}{1}$, $pm\frac{-}{2}$, $m\frac{-}{4}$.[5] The canine is large, erect and single fanged.

FIGURE 25. Left lower jaw of *Paurodon valens*, inner and outer view; three times natural size. *g*, mylohyoid groove. After Marsh

Behind this is a diastema followed by a small, first premolar. The second premolar

[1] Proc. Acad., Phila., June, 1887. This is probably equivalent to the *Paurodontidæ*, Marsh. I have substituted *Peralestidæ*, because the above family name implies a deficient number of teeth, which is the case only in *Paurodon;* secondly, the family definition, as given by Professor Marsh, would exclude the less modified British genera.

[2] "Mesozoic Mammalia," p. 33.

[3] "Mesozoic Mammalia," p. 40.

[4] "Am. Jour. Sc. and Arts," April, 1887, p. 342.

[5] It is probable that additional material will modify the formula, given above, to $pm\frac{-}{2}$, $m\frac{}{5}$, as there is a considerable space between $m\frac{}{4}$ and the anterior rim of the coronoid process. (Plate X, fig. 8).

has a single main cusp and a posterior heel apparently supporting a low basal cusp, as in *Peraspalax*. The molars have a single main, external cone, which is very slightly antero-verted, and has a distinct cingulum upon the outer face. The internal face supports a median cusp which rises to about half the height of the main cusp, a slightly lower anterior cusp and a heel-like process posteriorly. The lower jaw is short and massive, with a deep mylohyoid groove reaching the symphysis.

NOTE.—The molars of this genus resemble those of *Peraspalax* so closely as to leave little doubt of the family relationship between these genera, although *Paurodon* has but six, or at the most seven, post-canine teeth. The opposition of the *Peralestes* and *Peraspalax* cusps (see fig. 16 text) is probably such that the tip of the external cusp of a lower molar fits into the valley separating the cusps of an upper molar, and *vice versa*.

HERBIVOROUS SUB-GROUP.—The single family embraced in this sub-group is widely separated from those which we have been considering, by the unique character of the dentition. The inner aspect of the crowns is very similar to that of the *Stylodon* molars and the single specimen which represents this family was referred to this genus by Professor Owen. But the wearing surface of the crown is essentially different from that of *Stylodon* as it is wholly devoid of cusps and without any degree of trenchant function. The fangs are distinct and placed transversely and are in a line of modification which ends in growth from persistent pulps. The wearing pattern of dentine, traversed by ridges of enamel, resembles distantly that of the Rodents and more nearly that of the *Phascolomyidæ*, and we may infer that *Kurtodon* represents a class of animals which fed upon roots and other vegetable substances. The large size of the foremost tooth is, however, somewhat against this conjecture, unless it should prove to be not the canine but one of the lateral incisors.

KURTODONTIDÆ, Osborn,[1] 1887.

Molars without cusps, with compactly placed trihedral columnar crowns. Wearing surfaces flattened, with enamel ridges, indicating horizontal wearing action, as distinguished from vertical. Two or three fangs set transversely. Premolars rudimentary or sub-molariform.

This family embraces at present the single genus *Kurtodon*, of which only the maxillary dentition is known. It may be defined as above.

KURTODON, Osborn,[2] 1887.

Dentition—i $\frac{-}{?}$, c $\frac{-}{?1}$, pm $\frac{}{4}$, m $\frac{}{7}$. The first premolar is small, placed closely behind the canine and styloid. Behind this is a diastema followed by the rudimentary

[1] Proc. Acad., Phila., June. *Athrodontidæ*, Syn.
[2] Proc. Acad., Phila., June. *Athrodon*, Syn.

second premolar. The third premolar is larger with a sub-conical crown. The fourth premolar has two fangs which are partly rotated into a transverse position. The inner face of the crown is more lofty but otherwise resembles that of the first molar. The wearing surface of the molars presents an enamel V upon the anterior and posterior faces of the crown, diverging from the inner face, and bisected by a faint median ridge, apparently of enamel, which disappears, as it extends outwards.

SUB-ORDER INSECTIVORA PRIMITIVA.[1]

An extinct sub-order which is probably on the line of the primitive Placentalia, with tritubercular molars, forming alternating series in the upper and lower jaws. The nearest affinities in dentition are to some of the recent Insectivora.

INSECTIVOROUS SUB-GROUP.—This embraces the families *Amblotheriidæ* and *Stylacodontidæ*. The types of the former family are known by the inner surface of the mandibular rami only; and as this is in many respects similar to the corresponding surface of the *Stylacodon* types, the separation of these families is not fully established. The genera vary from an extremely small to middle size. The smaller genera embrace the typical insectivorous forms, in which the incisors are procumbent and spatulate, and the canines are very small. In the larger genera the incisors and canines are more pointed and erect. In the entire sub-group the premolars lack anterior basal cusps, the series increases rapidly in size, the last premolar being lofty and rising much above the anterior molar level as in many recent Insectivora. The molars have no internal cingulum; the internal face being smooth and tricuspidate. The condyle is very high and the coronoid is slender. The angle is slender and produced to a tip posteriorly. The mandible is shallow and tapers towards the symphysis. The dental formula departs little from the typical pm $\frac{}{4}$, m$\frac{}{8}$, in the various genera. The adaptation to an insectivorous diet is very evident in the procumbent incisor-canine series of *Stylacodon*, which indicates the presence of a protrusible tongue. The molars of *Dryolestes* show a striking resemblance to those of the *Chrysochloridæ*.[2] Another marked feature in this sub-group is the retention of four incisors, while in the carnivorous and omnivorous groups the lateral incisors are wanting in the upper Jurassic genera. It follows that this sub-group is sharply defined from the preceding ones.

AMBLOTHERIIDÆ,[3] Osborn, 1887.

Molars with two slender cusps in line and a posterior heel with an external cingulum, forming an overlapping series; no opposed cusps (so far as known). *Premolars*

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[1] Provisional; see Appendix.

[2] St. George Mivart, "On the Osteology of the Insectivora." Jour. of Anat. and Phys., vol. II, p. 151. It appears from Mr. Mivart's description that the lower molars of *Calcochloris*, "with a marked posterior process," resemble those of *Dryolestes* even more closely than do those of *Chrysochloris*.

[3] Proc. Acad., Phila., June.

with a prominent cingulum and sometimes distinct basal cusps. Median incisors elongate, diminishing laterally. Condyle lofty. Coronoid slender. Angle distinct, posteriorly placed, not inflected.

The family embraces *Amblotherium* and *Achyrodon*, which are among the smallest genera of the Purbeck group. The mandibular symphysis is shallow and the mylohyoid groove extends forward to it. As the inner surfaces only of the jaws are known there is considerable doubt as to the full structure of the teeth and of the true relationships of these genera. It is probable that some of the specimens which have been referred to *Amblotherium* are, in fact, portions of *Stylacodon*. A suspicion as to the identity of these genera is raised by the mere fact that all specimens of *Amblotherium* present inner surfaces, while all the *Stylacodon* specimens present outer surfaces. The proportions of the mandible are very similar but the incisor teeth are widely different. The determination of the systematic position of these genera depends upon the presence or absence of external cusps. The molars have a superficial resemblance to those of *Amphitherium*, but the distinction is very clear when the inner faces are compared, the *Amblotherium* molars lacking the internal cingulum and conspicuous cingulum cusp. The family may be defined as above.

AMBLOTHERIUM, Owen,[1] 1871.

Dentition.—i $_{4}$, c $_{1}$, pm $_{4}$, m $_{7}$. The incisors are widely separate and semi-procumbent. The canine has a single fang. The central molar cusps are rounded and retroverted at the tip. The premolars are slightly recurved and rise to the level of the middle molars.

ACHYRODON, Owen,[2] 1871.

Dentition—i $_{?}$, c $_{?}$, pm $_{?4}$, m $_{5}$. The third and fourth premolars rise much above the molar level. The central molar cusps are sharply pointed and turned forwards. The anterior cusps are also acute and the posterior cusps are more elevated than in the allied genus.

STYLACODONTIDÆ, Marsh,[3] 1879.

Upper molars with a single styloid internal cusp connected by divergent transverse ridges with a pair of external cusps, which are followed by a lower posterior cusp or heel. Lower molars reversing this pattern. Molars with two or three fangs set transversely, without internal cingulum. Incisors diminishing laterally, spatulate in typical

[1] "Mesozoic Mammalia," p. 29.

[2] "Mesozoic Mammalia," p. 37.

[3] The family *Stylodontidæ* was first proposed by Professor Marsh to embrace *Stylodon* and *Stylacodon* (Am. Jour. Sc. and Arts, 1879, p. 60). It is equivalent to the *Dryolestidæ* subsequently proposed by the same author (Am. Jour. Sc., p. 397, April, 1879). *Stylodon*, however (Owen, 1866), is preoccupied by Beck for a genus of Gasteropoda (Index Molluscorum Præsentis Ævi, &c., 1838), so that *Stylacodontidæ* may be substituted as the family name. This is further preferable to *Dryolestidæ*, because the type of *Dryolestes* is doubtfully distinguished both from *Phascolestes* and *Stylacodon* (or *Stylodon*).

genera. Coronoid slender. Condyle elevated. Angle small and separate, extending posteriorly without inflection.

This family embraces the closely allied genera *Stylacodon*, *Phascolestes*, *Dryolestes*, *Aesthenodon* and *Laodon*. While possibly embracing also the *Amblotheriidæ*, it is readily distinguished from the *Triconodontidæ*, *Peralestidæ* and *Amphitheriidæ* by the pattern of the molars, which consists of two or three internal cusps, the anterior pair of which are connected by transverse ridges with a single styloid external cusp, the upper molars reversing this arrangement. The definition is as above.

STYLACODON, Owen,[1] 1866.

Dentition.—i $_{4}$, c $_{1}$, pm $_{4}$, m $_{7 \text{ or } 8}$. The incisors have very much elongated spatulate crowns and are compactly placed. The canine is long and semi-procumbent. The premolars have pointed, recurved crowns, and are slightly separate. The inner face of the molars shows three internal cusps (Marsh). The species *S. gracilis* (Marsh) has a distinct eighth molar, which is represented by a fang in some of the English species,[2] showing that this tooth is probably late in coming into place. The jaw is very slender with a nearly straight, lower border, and very elevated condyle.

FIGURE 26. Left lower jaw of *Stylacodon gracilis*, Marsh; outer view, three times natural size.

PHASCOLESTES, Owen,[3] 1871.

Syn. (probable), *Dryolestes*, Marsh, 1878.

Dentition—i $_{4}$, c $_{1}$, pm $_{4}$, m $_{8}$. The incisors are separate with the crown expanding at the tip. The median is the largest, the second is the smallest, the third and fourth increasing in size. The canine is lofty and recurved. Behind this is a deep depression of the alveolar border, with two rudimentary premolars. The third and fourth premolars are very large. The first molar is very small. The matrix shows the impression of the external styloid cusps of m_5 to m_8. The jaw is massive with a rounded lower border. The *Dryolestes vorax*, Marsh (Am. Jur. Mamm., Plate IX, fig. 4), is very similar to *Phascolestes*, and it is probable that these genera will prove to be the same upon further evidence.

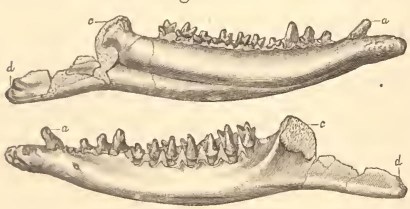

FIGURE 27. Left lower jaw of *Dryolestes vorax*, Marsh; outer and inner views, three times natural size.

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[1] *Stylodon*, Geological Magazine, or Monthly Journal of Geology, May, 1866, p. 199. Syn. *Stylacodon*, Marsh. "Am. Jour. Sc.," 1879, p. 60.

[2] See "Mesozoic Mammalia," p. 51. Also Plate II, fig. 18 *a*.

[3] Doubtfully separated from *Peralestes*, by Professor Owen, p. 35.

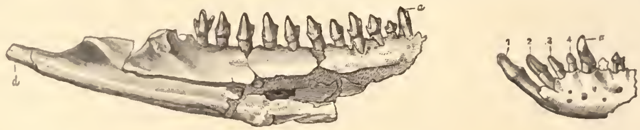
DRYOLESTES, Marsh,[1] 1878.

Dentition—i_{4}, c_{1}, pm_{4}, m_{8}. The angle of the jaw is slightly inflected. The lower jaw is massive and has a rounded lower border and elevated incisor alveolar border, as in the last genus. The condyle is concave transversely and slightly above the level of the teeth. The middle internal cusp of the molars is as high as or higher than the outer main cone. The canine is bifanged. The incisors are sub-erect and expand at the tip.

FIGURE 28. Left lower jaw of *Dryolestes priscus*, inner view; three times natural size. *a*, canine; *s*, symphysis. After Marsh.

ASTHENODON, Marsh,[2] 1887.

Dentition—i_{3}, c_{1}, pm_{3}, m_{8}. The median incisor is very large, the series being semi-procumbent and decreasing towards the canine. The canine is rather small.



A *B*

FIGURE 29. *A*, right lower jaw of *Asthenodon segnis*, inner view; *d*, angle. *B*, anterior portion of same outer view; three times natural size. *a*, canine. After Marsh.

The molars resemble those of *Dryolestes*, but lack the third postero-internal cusp; they are more uniform in size behind the first premolar which is rudimentary.

LAODON, Marsh,[3] 1887.

Dentition—$i_{?}$, c_{1}, $pm_{?5}$, m_{8}. The molars in this genus have the outer main cone high and pointed, but the inner opposite cusps are greatly reduced in size. The canine is bifanged. The lower jaw is intermediate in form between *Dryolestes* and *Stylacodon*. The angle of the jaw extends well backwards and is not inflected.

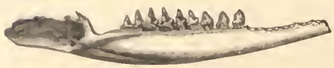


FIGURE 30. Left lower jaw of *Laodon venustus*, Marsh, inner view; four times natural size.

INCERTÆ SEDIS.

The genus *Leptocladus* is isolated from the remainder of the jurassic group and yet is not sufficiently characteristic, or well known, to be placed in a distinct family.

[1] "Am. Journ. Sc. and Arts," 1878, p. 459. These three genera are chiefly described from the figures and text of Professor Marsh's article, and in part from his previous papers. It seems rather improbable that *Laodon* had five premolars, as it would in such case form an exception to the entire sub-group.
[2] "Am. Jur. Mamm.," pp. 336 and 337.
[3] "Am. Jur. Mamm.," pp. 336 and 337.

LEPTOCLADUS, Owen,[1] 1871.

Dentition—pm $_{\overline{4}}$, m $_{\overline{6}}$. The lower premolars have a recurved main cusp with a faint cingulum upon the anterior slope and a posterior basal heel. The molars have a faint external cingulum and two fangs. The main cusp is elevated, and recurved. The second cusp forms a wide, low posterior heel, which is barely distinct from the cingulum, extending around the outer face of the crown.

III.—THE ORIGIN AND SUCCESSION OF THE TEETH IN THE MESOZOIC MAMMALIA.

The tooth forms have been so fully discussed in the preceding section, in their bearing upon classification, that it remains here first to briefly recapitulate the different types; second, to point out their probable origin and succession.

B.—Second Group.

Incisors and Canines.—In its entire dentition *Dromotherium* is separated from the whole jurassic group. The incisors are caniniform and widely separate, increasing rapidly from the median incisor to the canine. In the Stonesfield Slate genera, the earliest of the English jurassic, *Amphitylus* and *Phascolotherium*, the incisors differ widely; they are styloid and separate, while in the later *Triconodontidæ* they become close set, recurved and prehensile. Other degrees of specialization have been pointed out in the *Stylacodontidæ*. The frequency of the bifanged canine, in all the subgroups, reverts to an earlier, homodont condition in which the canine was less differentiated from the premolars. In *Phascolestes* the median incisor also has a grooved fang. In *Amphitylus* the canine is apparently premolariform. In the Stonesfield Slate genera, the canine is usually small, and resembles a large premolar, but it assumes large proportions in the upper jurassic genera.

Premolars and Molars.—The *premolars* of *Dromotherium* are very unique. They are tall and styloid and single fanged; the last premolar has a vertical groove upon the posterior face. In *Microconodon*, which belongs to a somewhat more recent type, the premolars have a faint posterior heel and the last shows the trace of a double fang. In all the jurassic genera the premolars, where fully functional, are bifanged, and possess a convex anterior face and concave posterior slope terminating frequently in a heel. As in the molars, the cingulum plays an important part in connection with the basal cusps. It is present upon the internal face of the premolars of all the

[1] "Mesozoic Mammalia," p. 53. *Leptocladus dubius.*

jurassic genera except *Kurtodon*, and is observed upon the outer surface in *Diplocynodon*. It thus in many cases enables us to draw the line between premolars and molars, as in both the *Peralestidæ* and in the genera of the Insectivorous Sub-group the inner faces of the molars are smooth. The cingulum generally embraces the entire inner face of the crown, forming anterior and posterior cingulum cusps or *cingules*,[1] which are characteristic of the insectivorous forms, while in the supposed carnivorous and omnivorous forms, distinct basal cusps rise posteriorly and sometimes anteriorly (*Triconodon*) above the cingulum. As in the latter genera the cingulum is present with the basal cusps, it probably precedes them in evolution, but there is no direct evidence of the conversion of *cingules* into true basal cusps, such as we find in the molars. A review of the premolars of all the genera shows that they are sharply distinguished from the incisors and from the molars and less distinctly from the canines in many instances. In several genera they have undergone considerable specialization, as in the production into lofty cones of $pm_{3,4}$ of *Achyrodon* or the apparently incipient assumption of the molar pattern in *Kurtodon*.

Molars. If *Dromotherium* is a mammal, as there may be some question, it is the most reptilian in type of dentition in several respects: first, there is no internal cingulum upon either premolars or molars. Second, the premolars have single fangs, which may, by the way, indicate that the division of the fangs in the premolar-molar series extended from behind forwards; third, the division of the molar fangs is incomplete, the molars are, strictly speaking, single fanged so far as they are exposed to view; fourth, the incisors are more reptilian than mammalian in appearance, resembling those of some piscivorous reptiles, or the homodont series of some of the *Delphinidæ*; finally the molar crowns, although tri- or polycuspid, plainly revert to the monocuspid condition. The lateral cusps of the main cone are irregular in size and development and appear to present an experimental stage which is transitional between the single reptilian cone and the tricuspid, or parent mammalian molar crown, as seen in *Microconodon*.

In the Theromorph reptiles, among which Professor Cope has found many mammalian characteristics, although it is improbable that the mammalia can be derived directly from them (Baur[2]), as already observed upon page 222, we find the teeth implanted in distinct sockets with the bases deeply grooved upon the inner and outer faces, (*Dimetrodon*). The crown is a single cone with a flattened section and serrate edge, with no trace of lateral cones; from this condition we must infer that the primary division of the fang resulted from some mechanical cause other than the fore and aft rocking following the production of lateral cones. In other words the division

[1] A very useful term introduced by Harrison Allen. "Studies in the Facial Region." Dental Cosmos, (1875, p 112.)

[2] "Ueber die Abstammung der Amnioten Wirbelthiere." Munich, March 8th, 1887.

of the fang preceded the division of the crown.[1] Starting then with the assumption,[2] which the *Dromotherium* dentition seems to support, that the primitive mammals had monocuspid molars with incompletely divided fangs, we observe four distinct lines of modification in progress in these pre-cretaceous mammals; these are partly in the nature of progression from the reptilian condition and partly in the acquisition of changes of form leading directly towards the modern mammalian type of molar. 1° The division of the fang, followed in some cases by a rotation of one of the fangs from a fore and aft to a transverse position with relation to the other and a further subdivision. 2° The development of the internal cingulum. 3° *a* The growth of anterior and posterior cusps upon the faces of the primitive cusp, *b*, the rotation inwards of the lateral cusps to form a triangular crown. 4° and 5° The growth of internal cusps from the internal cingulum to form a crown with transversely opposed cusps.

1.° The first stage of the evolution of the *fang* is seen in the Triassic genera. The second stage, in which the fangs are entirely distinct and in the same fore and aft line, is seen in all the lower Jurassic (Stonesfield slate) genera. The upper Jurassic genera present three types of modification of the molar fangs. In the *Triconodontidæ* and *Amphitheriidæ* the fangs are in the same fore and aft line, conforming to the simple condition of the crowns. In the *Kurtodontidæ*, so far as it is possible to determine their relations, the fangs are placed opposite each other, i. e., transversely, and are somewhat connate; possibly the crown is passing into a prismatic condition, with a single pulp cavity; but this inference must be taken with reservation. In the *Stylacodontidæ* the fangs are also opposite; in the lower molars there is but a single fang seen upon the outer face beneath the protocone; on the inner face, however, there are two fangs visible beneath the para and metacones; it is a question, whether one of the latter may be connate with the outer fang[3]; if not, these molars are three-fanged, and have in this respect already acquired the higher mammalian condition.

2.° The *internal cingulum*, as already observed, is wanting upon the *Dromotherium* molars, but is, possibly, present in *Microconodon*. As a general law, the internal cingulum is present upon the molars of all the Jurassic genera in which the cusps are not transversely opposed, and absent in molars in which the cusps are thus opposed. Examples of these two types are seen among the *Triconodontidæ*, in which the cingulum is most strongly developed, and the *Stylacodontidæ*. This law, which may find

[1] This point has been ably discussed by Wortman, "Comp. Anat. of the Teeth of the Vertebrata." Am. Sys. of Dentistry, 1886, p. 420.

[2] Oldfield Thomas, "On the Homologies and Succession of the Teeth in the Dasyuridæ," Phil. Trans. 1887, p. 456, is inclined to adopt the Baume hypothesis, that in their first stage, mammalian teeth are simple cones, rootless for part if not the whole of the animal's life.

[3] I have not been able to examine these fangs very minutely. Marsh describes these molars as bifanged: "Seen from the outside, these teeth appear to be inserted by a single fang, but, in most cases, each has two roots, although these are nearly or quite connate." Amer. Jour. Sc., April, 1887, p. 335. Several of the specimens seem to present two well-separated internal fangs. If either is connate with the external fang, it is probably the most anterior, since the posterior would probably be developed beneath the third cusp, or heel.

an exception in *Amblotherium*,[1] applies also to the *Peralestidæ*, and lends support to the theory, discussed below, that the internal cusps of the *Peralestes* type are products of the cingulum. In the *Amphitheriidæ* the crown spreads at the base into the cingulum; and this is either crenate, as in *Diplocynodon*, or has a median elevation, which Professor Owen has described as a cusp,[2] as in *Amphitherium*. The internal cingulum, while invariably present upon the premolars of the Jurassic genera, is thus either wanting altogether; or, strongly developed and yet retaining its primitive character; or, well developed and in course of transformation into a row of internal cusps.[3]

3.° *a*. If, as now seems probable, the derivation of the mammalian molar from the single reptilian cone can be demonstrated by the comparison of a series of transitional stages between the single cone and the three-cone type, and from the latter to the central tritubercular type, the separate history of each cone can certainly be traced throughout the series in its various degrees of modification, development, and degeneration. The remarkable part played by the tritubercular molar has been unfolded by the discoveries and writings of Cope. It is undoubtedly the ancestral molar type of the Primates, the Carnivora, the Ungulata, the Cheiroptera, the Insectivora, and of several, if not all, of the Marsupialia. For example, we can trace back the quadritubercular bunodont, or parent ungulate type, to the *tritubercular*; this to the type with three cones in line, which we may call the *triconodont* type, and this in turn to the *haplodont*[4] reptilian crown. A nomenclature may be suggested for these cones, with reference to their order of development and primitive position, to keep clearly before the mind their homologies during secondary changes of form and position. The primitive cone may be called the *protocone*; upon the anterior and posterior slopes of which appear, respectively, the *paracone* and *metacone*. After the tritubercular crown is produced, by the rotation of the lateral cones, inwards in the lower jaw and outwards in the upper jaw, the *hypocone*, or heel, is developed, giving us the tubercular-sectorial molar. Exclusive of the *Multituberculata* and of *Stereognathus*, this is the most advanced stage of molar development thus far found in the mesozoic period.

The protocone of *Dromotherium* (Plate IX, fig. 17) is prominent and constant

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[1] Lydekker has observed a minute inner cusp to the blade of the hinder lower true molars of *Amblotherium*, in some cases; (*A soricinum*). Cat. of Foss. Mamm. Part V, p. 274. This apparently is an exception to the rule.

[2] " Mesozoic Mammalia, p. 14.

[3] Wortman (" Dental Anatomy," p. 418,) writes: "The various steps in this process of dental evolution I conceive to have been as follows: (1) Additions to the anterior and posterior edges of the cone and formation of a cingulum. (2) Division of the single root into two. (3) Addition of basal cusps from the cingulum. Long continued vertical pressure, I believe to be an adequate cause for the appearance of the wrinkle or fold of the enamel covering at the base of the tooth, which is designated as the cingulum." These stages, which in part had been pointed out by Cope and Allen, coincide remarkably with the actual condition of the molars in the Mesozoic Mammalia.

[4] See Cope: "The homologies and origin of the types of molar teeth of the Mammalia Educabilia." Jour. Phila. Acad., 1874.

through the molar series while the para and metacones are irregular in size and position, always close to the main cone and in several teeth either splitting into two needle-like cusplets or bifid at the tip. Altogether, they are in what appears to be an experimental stage of development. *Microconodon*, however, from the same strata, has well defined para and metacones which are widely separated from the main cone, the crown presenting the pure triconodont type. This reoccurs in *Amphilestes*, of the lower Jurassic, and *Triconodon* of the upper Jurassic. In this series we are struck by the gradual increase of size and prominence of the lateral cones until they are upon the level of the main cone and sub-equal to it, this increase being accompanied by a marked elongation of the crown so that the three molars of *Triconodon* occupy a greater proportion of the jaw than is taken by the seven molars of *Dromotherium*. This unmodified triconodont type is very rare in the more recent mammalia. It persists in the lower jaw, at least, of *Dissacus* from the Puerco, and in the lower molars of *Thylacinus*, the upper molars presenting an internal heel.

b. In his paper upon the *Creodonta*,[1] Cope observed that the *Spalacotherium* molars represent a stage of transition between the triconodont and tritubercular molars. There can be no doubt that the cusps seen upon the inner face of the inferior molars of this genus are homologous with the para and metacones and there are several facts which support Cope's hypothesis that they represent a stage of inward rotation of cusps which were at an earlier stage in the same fore and aft line with the main cusp. These are, that in *Phascolotherium* the lateral cones are seen to be slightly internal to the main cone so that their median slopes descend upon the inner face; in *Tinodon*, of a later geological period, this disposition is slightly more pronounced; in *Menacodon* it is still more marked but less so than in *Spalacotherium*. These genera, although evidently in two different lines of descent, afford the desired transition stages. The *Spalacotherium* molar as seen from above[2] has a striking resemblance to the anterior sectorial triangle of the *Stypolophus* or *Didymictis* molar of the Puerco. It is in fact sub-triangular, the superior molars probably having the lateral cones rotated outwards, so that the upper and lower molars form an alternating series, the ridges connecting the main and lateral cones acting as sectorial blades.

The question now arises whether the *Stylacodon* molar represents the next higher stage of development, viz. the tubercular-sectorial molar in which the anterior triangle is followed by a low heel. And if so has the *Stylacodon* type passed through the stages of inward rotation of the lateral cusps? The superior aspect of the *Stylacodon* molar presents an anterior triangle with the long styloid cone forming the apex and connected by divergent ridges with the anterior pair of cusps; behind these is a third cusp not connected by a ridge with the styloid cone. In the upper jaw the three cusps are external and the single cone internal, these relations are reversed in

[1] "The Creodonta," American Naturalist, 1884, p. 259.

[2] Owen. "The Mesozoic Mammalia." Plate I, fig. 32c.

the lower jaw. We cannot well avoid the inference that the *Stylacodon* lower molar is a specialized tubercular-sectorial, that the styloid external cusp, which until Marsh's discovery of *Dryolestes* was regarded as the single summit of the crown, is the protocone while the anterior pair of internal cusps represent the paracone and metacone, followed by a third element the hypocone or heel. This is further confirmed by the transition to the simpler *Spalacotherium* type seen in the molars of *Asthenodon* in which the hypocone is entirely wanting while the remainder of the crown is closely similar to that of *Stylacodon*. The internal cusps present many degrees of development in different members of the *Stylacodontidæ*; in *Laodon* they are much less prominent than in *Dryolestes*, the heel being also inconspicuous. While the relations of the four cones composing the Stylacodont crown strongly suggest the tubercular-sectorial molar there is one matter of doubt in the way of the derivation of this tooth from the *Spalacotherium* type; that is, the position of the fangs. In *Spalacotherium* and *Menacodon* the fangs are paired and placed beneath the para and metacones. In the Stylacodonts the external fang is directly beneath the protocone; the question is does this represent the anterior or posterior, or an additional fang?

4.° The molars which have been considered thus far show directly or indirectly the triconodont type, *i. e.*, the presence at some stage of their evolution of the central and two lateral cones. In the *Amphitheriidæ* it is clear that the main cone and the lesser one, upon its anterior slope, represent the protocone and paracone but it is uncertain whether the basal cusp, seen for example upon the external face of the *Diplocynodon* molar, is homologous with the metacone or hypocone. The latter alternative excludes the development of the metacone or the passage of these genera through a triconodont stage and implies a considerable separation of the *Amphitheriidæ* from the stem of the two families already considered. The former involves the supposition that the metacone has metamorphosed into a heel. The most primitive molar in this family is seen in *Enneodon*[1] The crown has an obtuse recurved protocone, more like that of a premolar; upon the anterior slope is a rudimentary paracone which affords the only means of distinguishing the molars from the premolars. The posterior slope terminates in a low extended heel. This molar pattern largely confirms the second of the above alternatives, *viz*, that this heel is to be compared to the hypocone of the tubercular-sectorial crown. Further confirmation is seen in the fact that this heel is not above the level of the internal cingulum, as in the metacone of all the triconodonts, but is continuous with the broad shelf-like projection of the internal cingulum, which is well represented in the internal aspect of the *Diplocynodon* molars. The concave internal slope of the protocone descends into this shelf and the cingulum rises at the margin into numerous crenations, which cannot properly

[1] Marsh, "American Jurassic Mammals." Am. Jour. Sc., April 1887. Pl. X, fig. 4.

be called cusps. The *Diplocynodon* molar presents a decided advance upon that of *Enneodon* in the development of the paracone, which is much more prominent. In *Amphitherium* (text, fig.2), the paracone is subequal to the protocone in several of the molars, and the heel is on the level of the internal cingulum, from which, according to Owen, there arise one or two small cusps.[1] Internal cusps which develop in this manner are from the first separated from the external cusps by a longitudinal valley instead of being united with it by divergent ridges, and cannot therefore at any stage possess a sectorial blade, such as is more or less distinctly developed in the *Spalacotherium* and *Stylacodon* molar.

5°. It follows also that the triangle of cusps presented by the *Peraspalax* molar cannot, with probability, be considered as representing a tritubercular stage and that the *Amphitheriidæ* furnish the key to the mode of derivation of the internal cusps of the molars of the *Peralestidæ*. The inferior molars of *Peraspalax* and *Paurodon* are apparently very similar (see Pl. VIII, fig. 9, m_6, and fig. 9, text), consisting of a prominent external cone, and two internal cusps followed by a third cusp at the end of the crown. As pointed out in the synopsis of molar types, this internal surface strongly suggests the *Dryolestes* pattern, but may be clearly distinguished by the absence of transverse ridges and the presence of a longitudinal valley between the cusps instead of a transverse valley opening inwards. The internal cusps have probably, therefore, arisen from the internal cingulum[2], but these molars do not seem to be a later development of the *Amphitherium* type because both the paracone and metacone are wanting, the main cone showing no trace of the lateral cusps upon its slopes. The superior molars of *Peralestes*, however, when viewed from above (Plate VIII, fig. 8), present one large internal and two smaller external cusps disposed in a triangle opening outwards, and as this is the general disposition of superior cusps of the tritubercular type, we must admit the possibility that the smaller cusps do represent the para and metacones in a stage of inward rotation not accompanied by the production of the sectorial blades, for this is by no means an essential feature of the tritubercular molar. The history of the derivation of the molars of the *Peralestidæ* must, therefore, be left in some doubt; while the balance of evidence points to a line of development similar to that in progress in the *Amphitheriidæ*, although the line of descent appears to be different.

[1] As previously stated, the writer has not personally examined the internal surfaces of the molars of this genus.

[2] Numerous instances of the origin of molar cusps from the cingulum might be cited. One of the most important is seen in the transition from a tritubercular to a quadritubercular superior molar by the addition of the postero-internal cusp which is primitively a cingule; this was first demonstrated by Dr. Harrison Allen, op. cit. Mivart (Jour. of Anat. and Phys., Vol. II, p. 138), shows how the four cusps of the Insectivore molars are frequently fortified by additional cusps from the cingulum.

Reviewing this study of the molars the following are the principal deductions: (a) The molars of all the mesozoic mammals of this group presents one main cusp which is either so central or so prominent that it may be considered homologous with the single reptilian cone or protocone. (b) In one line of genera two lateral cusps, the para and metacones, appear upon the anterior and posterior slopes of the protocone. This is a central and frequently repeated stage of evolution. It gives rise to two lines of molar development; in the first, the para- and metacones are retained in the same fore and aft line, as the persistent triconodont type, but increase greatly in size; in the second, they are rotated inwards as the tritubercular type, which finally acquires a heel. (c) In a second line of genera the paracone appears upon the anterior slope of the protocone but the metacone is not developed, being replaced by a basal talon or hypocone which extends inwards to form the internal cusp. (d) In a fourth line of genera neither the para- nor metacones are developed upon the sides of the protocone, but they are replaced by basal cusps derived from the cingulum.

Reduction and Succession of the Teeth.

The homologies of the molar cusps naturally have an intimate bearing upon the phylogenetic problems, *i. e.*, of the relations of these families of mammals to each other and to a common primitive stock. It must be constantly kept in mind, however, that like mechanical or functional forces produce like effects, so that we may almost assume that the triconodont and tritubercular type has appeared independently in widely different phyla. To counteract errors which may arise from this law of development, valuable data are afforded by a comparison of the dental series as a whole, in the genera embraced in the different mesozoic families, with respect to the retardation, atrophy, suppression, acceleration[1] and hypertrophy of the teeth. These terms are here employed to express, first, the relatively late time of appearance of a tooth in its adult position; second, the relative decrease in size of a tooth as compared with its fellows of the same series; third, the loss or absence of a tooth; fourth, the relatively early time of appearance; finally, the increase of size from excess of nutrition. Thus retardation and acceleration, atrophy and

[1] Cope has employed "acceleration" in a larger sense as expressing an increase or addition of parts as well as an increase of rate of growth (Proc. Phila. Acad., 1876, p. 15). But in the dental series, as lately observed by Oldfield Thomas (loc. cit., pp. 452–3), an increase of size is frequently preceded by a relative decrease or retardation in the rate of growth; the term must be here used in the more restricted sense. Kowalevsky has employed "reduction" in all his memoirs to express the process of loss of one of a series of teeth or limb members, and this term has now come into universal use. We may describe a dental series as reduced, *i. e.*, from the typical complement of the teeth, in which one or more teeth have been suppressed. Atrophy is frequently used as equivalent to "suppression," but may better retain its original significance. As all changes result from a transfer of nutrition they may be described as metatrophic.

hypertrophy, expressing reverse conditions, ultimately result either in suppression or retention.

	Mandibular Dentition. i.	c.	p.	m.	p.&m.	Total Dentition Estimated.	Reduction &c. of Dental Series.
PROTODONTA.							
Dromotheriidæ.							
Dromotherium.	3	1	3	7		56	
Microconodon.			?3	?7			
PRODIDELPHIA.							
1. *Triconodontidæ.*							
a. Amphilestes.	4	1	4	7		64	
Amphitylus.	4	1	4	7		64	
Triconodon.	3	1	4	4–3		48	i_4 suppressed. m_4 retarded or suppressed.
Priacodon.*		1	?3	4–3			p_1 suppressed " " "
b. Phascolotherium.	4	1	......	......	7	48	premolar series extremely reduced or suppressed.
Tinodon.		1	......	......	?8		" " reduced.
c. Spalacotherium.	?3	1	4	6		56	i_4 suppressed.
Menacodon.*		1	?3	?4			p_1 suppressed.
2. *Amphitheriidæ.*							
Amphitherium.	?4	1	4	6		60	
Diplocynodon.	3	1	4	8		64	p_2 atrophied, m_8 atrophied.
Docodon.*	3	1	4	7		60	" " m_8 suppressed.
Enneodon.	3	1	3	6		52	p_2 suppressed, m_{7-8} suppressed.
Peramus.			......	......	9		
3. *Peralestidæ.*							
Peralestes.		1	4–5	6			
Peraspalax.		1	4	7			
Paurodon.		1	2	5			p_{1-2} suppressed, m_{6-8} suppressed?
4. *Kurtodontidæ.*							
Kurtodon.		?1	4	7			p_{1-3} atrophied, p_4 hypertrophied.
INSECTIVORA PRIMITIVA.							
5. *Amblotheriidæ.*							
Amblotherium.	4	1	4	7		64	p_1 atrophied, p_4 hypertrophied, m_1 atrophied.
Achyrodon.			4	8			p_{3-4} "
6. *Stylacodontidæ.*							
Stylacodon.	4	1	4	7–8		68	m_8 atrophied.
Laodon.		1	?5	8			
Phascolestes.	4	1	4	8		68	p_1 atrophied, m_1 atrophied.
Dryolestes.	4	1	4	8		68	" " " "
Asthenodon.	4	1	3	8		64	p_1 suppressed, " "
7. Leptocladus.			4	6			

*These types may be immature.

From this table it is seen that the prevailing or typical dental formula in these mammals is $i_{\bar{4}}$, $c_{\bar{1}}$, $p_{\bar{4}}$, $m_{\bar{8}}$. The incisors in no case exceed four. The premolars in the large majority of genera are either four or have recently been reduced to three; in two cases in which the determination of the teeth is somewhat uncertain, five premolars have been observed; the only other exceptions are in the *Dromotheriidæ*, in which the premolars number three only. The molars are less constant, varying from 8-7 in all the more ancient genera to 4-3 in some of the more recent.

The mode of reduction is by no means uniform in the different families but varies little within the limits of the families themselves and certainly tends to strengthen rather than impair the family boundaries adopted in this memoir.

In the *Triconodontidæ* there are four incisors in the earlier genera which are reduced to three in the later forms, probably by the loss of i_4. The reduction of the premolar series seems to have been at the expense of p_1, for this is the smallest tooth where it is present and is replaced in *Priacodon* by a diastema behind the eanine. In the *Phascolotheriinæ* the mode of reduetion is unknown. In the *Spalacotheriinæ* it is again the first premolar which has been suppressed. The mode of reduetion of the molars in this family is not certainly known but probably took plaee from behind forwards. This is eertainly in process in *Triconodon* in whieh m_4 is very mueh retarded in some speeies, if not actually suppressed.

In the *Amphitheriidæ*, the mode of ineisor reduetion is unknown. We find the premolars reduced at the expense of p_2, whieh is atrophied in *Diplocynodon* and *Docodon* and suppressed in *Enneodon*. The reduetion of the molars is obviously from behind forwards, *Diplocynodon* having the typical number and *Enneodon* falling two short of it.

In the *Peralestidæ* the dental formulæ are uneertain. Judging from the diastema behind the canine, it would appear that the premolar series of *Paurodon* has been redueed by the loss of p_{1-2}.

In *Kurtodon* the typical number of premolars is present but the atrophy of the three most anterior, p_{1-3}, is in marked contrast with the hypertrophy of p_4.

General characteristics of the *Insectivora Primitiva* are the apparently constant atrophy of the anterior pair of premolars and hypertrophy of the posterior pair, and the reduction in size of the molars at both ends of the series, aecompanied by a retention of all the incisors, and the typical number of molars.

In the *Amblotheriidæ* the first premolar is extremely small and the molar series increases regularly in size from before backwards. In the *Stylacodontidæ* the ineisors are unreduced, but a slight hypertrophy of the median incisor is almost a constant feature, with a corresponding atrophy either of the seeond or fourth ineisor. The first premolar is atrophied in three genera, so that there is little doubt that this is the tooth which is suppressed in *Asthenodon*, in whieh there are but three premolars. The seeond premolar is also small. Adjoining the hypertrophied posterior pair of premolars is usually found a very small first molar; the last molar is retarded in development and is generally small, so that although there is no ease in which either of these teeth has been suppressed, we may assume that the molars are in course of reduction at both ends of the series.

These observations are subject to be modified by the diseovery of new material but are eertainly of very great interest in their present shape. The diverse modes of extreme reduction in the different families are summarized as follows: The *Triconodontidæ*[1] lose the lateral (?) incisor and first premolar and the reduetion in the molar series is from behind forwards. The *Amphitheriidæ* lose the fourth (?) incisor, the second premolar is suppressed and the reduction in the molars is from behind forward. The *Kurtodontidæ* suffer atrophy of the foremost three premolars. The *Stylacodonti-*

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[1] Excepting the *Phascolotheriinæ*.

dæ retain four incisors, the first and second premolars are atrophied, or the first suppressed, and the atrophy of the molars is at both ends of the series.

The only instance in which a vertical replacement of the teeth has been observed is in the genus *Triconodon*, fully described upon page 198 of this memoir, which succession is confined to the last premolar, precisely as in the modern marsupials. *Priacodon* may prove to present a similar mode of succession.

General Conclusions.

1. The primitive mammalia, ancestral to the known Jurassic mammals, were heterodont. The teeth were without diastema and divided into three series, incisors, premolars and molars. The incisors were separate and inserted by a single fang. The premolars had single or grooved fangs and simple conical crowns; the addition of cusps took place at the base of the crown in connection with the internal cingulum; first, by the addition of a heel and its elevation into a posterior cusp; second, by the addition of an anterior basal cusp. The molars had grooved fangs and simple conical crowns; the additional cusps were found upon the anterior and posterior slopes of the crown above the base, or upon a heel from which secondary cusps arose as in the premolars; or the development of secondary cusps was wholly at the base of the crown. Canines were differentiated from the first member of the premolar series, and at first were distinguished by their larger size from the first true premolar, subsequently by the coalescence of the paired into single fangs.

2. The complication of the molar crowns increased from before backwards, and conversely the primary division of the fangs probably took place from behind forwards, first in the molars, then in the premolars but not extending to the incisors. Rotation of one of the fangs inwards and triple division of the fangs, accompanied the development of internal molar cusps.

3. The typical dental formula was i 4, c 1, p 4, m 8. Reduction of this formula was effected by the loss of the lateral incisors, resulting possibly from the hypertrophy of the adjoining canine; the premolars were reduced by regular antero-posterior suppression (*Phascolotherium* ?), or by the loss of the first or second member of the series; molars were reduced either by antero-posterior or by postero-anterior reduction or by simultaneous reduction of both ends of the series.

4. The complication of the molar crowns and specialization of the dental series into the four sharply defined groups, incisors, canines, premolars and molars took place independently of reduction, *i. e.*, some of the genera in which the dental groups were most sharply defined, retained the typical formula. The specialization of the incisors and canines for different functions, in different genera, proceeded with comparative rapidity. The premolars were the most conservative members of the series, retaining longest the primitive common pattern. The molar differentiation proceeded

most rapidly along diverse lines as conditioned by the mode of addition of secondary cusps to the primitive cone.

5. The starting point of the molar crowns can now be assumed to be the single cone, but our present evidence does not support the hypothesis that there was but one mode of addition of cusps to this cone. On the other hand, as described in detail in the foregoing sections, we find evidence of three or more modes of addition.

a. In one series, to which the larger number of genera belong, lateral cusps were added upon the anterior and posterior faces of the protocone, forming the *triconodont* type. This type persisted in one line of genera (*Triconodon*), with a gradual increase of the lateral cusps or para- and metacones. In another line of genera the para- and metacones were rotated inwards to form the *trituberculur* type (*Spalacotherium*, *Asthenodon*). In a third line of genera, this process was probably completed before the upper jurassic period, together with the addition of a heel, forming the *tubercular sectorial* type (*Stylacodon*).

b. In a second series, only the anterior cusp or paracone was developed upon the protocone, the metacone being replaced by a heel which became continuous with the internal cingulum, and the latter gave rise to internal cusps (*Amphitherium*).

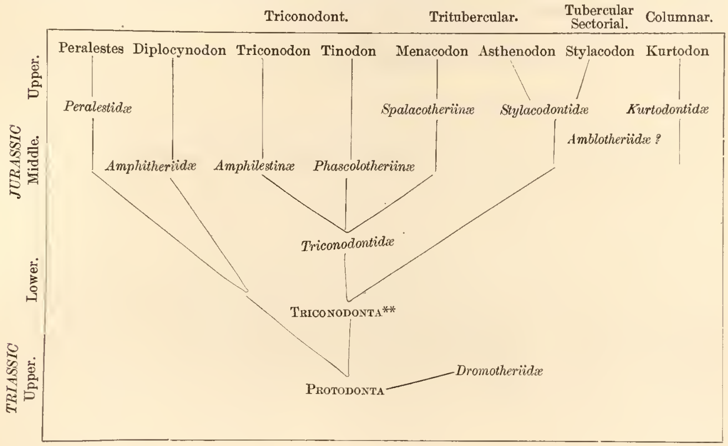
c. In a third series, neither the paracone nor metacone were developed upon the protocone but the crown was reinforced by the development of cusps from the posterior heel and from the internal cingulum. Or, the postero-internal basal cusp represented the metacone and the antero-internal the paracone (*Peralestes*).

d. In a fourth series, represented by the single genus *Leptocladus*, there was simply an elongate heel behind the main cone, the molars having the same general pattern as the premolars.

e. The mode of development of the prismatic columnar crown of the genus *Kurtodon*, is unknown. It may have sprung from the trituberculur type, in which a complete union of the internal cusps has left a record of the transverse valley in the line of enamel extending across the crown.

The following is an hypothetical scheme of the mutual relations of the Mesozoic families and genera, founded upon the homologies and reduction of the teeth, as considered most probable in the above analysis. It is intended, not to show the actual line of succession, for our palæontological record is far too imperfect for such an attempt, but as an outline of a *possible line of succession* in which the genera are taken merely as types representing certain stages of development of the molars. At the same time, the diagram does express the author's present views of the degree of separation of the families from each other. There is, for example, little doubt that the *Stylacodontidæ* have diverged from the common stem at an early period, since they present the most modern type of molar known at this period, excepting perhaps the *Kurtodontidæ*. The central line is through the *Triconodontidæ*. The *Spalacotheriinæ* and *Phascolotheriinæ* may have branched from this. The position of the *Amphi-*

theriidæ and *Peralestidæ* depends entirely upon the homologies of the cusps. The position of the *Amblotheriidæ* is also uncertain, since their molar structure is not fully



**Hypothetical.

known. The *Dromotheriidæ*, the only representatives of the Protodonta, are considered somewhat aberrant because of the wide diastema behind the canine and the presence of but three premolars.

A.—First Group.

We have at present but little insight into the derivation of the multituberculate dentition. In the oldest known genera the dental series has already undergone considerable reduction and a much higher degree of specialization than is attained by any of the mammals of the recent group. The most prominent features of the dentition are the hypertrophy of a pair of incisors in each jaw, the atrophy of the remaining incisors and the canines, the reduction of the premolar series, the longitudinal rows of tubercles upon the molars and the wide diastemata.

Incisors.—Among the genera in which the mode of reduction has left any record we find the second incisor, or rather one of the lateral incisors hypertrophied. In the Bolodontidæ, as demonstrated by Marsh in his observations upon *Allodon*, the median incisor is atrophied and the *second* incisor hypertrophied. In *Bolodon* the median incisor is apparently suppressed, and the third is much smaller than the second. Of the two incisors in *Tritylodon*, the outermost is close to the maxillary suture, the hypertrophied incisor is close in front of this and widely separate from its opposite fellow, indicating that if this genus is descended from a form with three or four incisors, as a comparison with *Bolodon* renders probable, it is again the median incisor which has disappeared. We have no further evidence bearing upon this point, so it will be of importance to ascertain which of the incisors is hypertrophied in *Plagiaulax*. The lower incisors in *Polymastodon* and *Plagiaulax* are reduced to a single pair.

The *canines*, if present in the previous history of this group, have been entirely suppressed in the known forms, with the possible exception of *Plagiaulax*.[1]

Premolars. It is interesting to find in the early *Plagiaulacidæ* the typical number of four premolars. There are three premolars in *Bolodon*, *Allodon* and *Chirox*, probably two in *Tritylodon*, and one in *Polymastodon*. There was undoubtedly a regular antero-posterior reduction of this series, accompanied in *Plagiaulax* only, by the hypertrophy of p_4. The tritubercular crowns of p_{2-4} in *Bolodon* are replaced in *Chirox* by three tubercles upon p_2 and four upon p_{3-4}. A hint as to the possible derivation of the trenchant premolars of *Plagiaulax* from tubercular forms, is obtained by a study of the superior premolars of *Ctenacodon serratus* (Fig. 8), and comparison of the same with the first pair of molars of *Bolodon* (Plate IX., fig. 16). In the former, the trenchant margin is composed of four distinct tubercles; in the latter, the internal row of tubercles is partially obliterated by vertical wear of the inferior teeth.

Molars. The structure of the molars is associated with that of the incisors. An almost universal characteristic is the fore and aft grinding motion between the upper and lower rows of tubercles. Professor Marsh recently called the writer's attention to the wearing of the posterior face of the large upper incisor of *Allodon* by the tip of the lower tooth. The same relation obtains in nearly all the other genera, and causes an interference which forces the jaw backwards as it ascends, by a mechanism similar to that in the rodents, as demonstrated by Professor Cope.[2] This fore and aft grinding motion was found in the Tritylodontidæ, Bolodontidæ and, later Plagiaulacidæ; it is observed in a transition stage from a fore and aft to a circular grinding motion in the Polymastodontidæ. The most primitive molar crown known is that of *Microlestes*. In this the tubercles are not very numerous and one is much more prominent than the remainder (p. 214); this inequality is also observed in the primitive *Plagiaulax minor* molar, with four tubercles and trace of a cingulum, but in the more recent genera the tubercles are subequal, the crown is elongate, tubercles being added posteriorly. In the Tritylodontidæ and Bolodontidæ the tubercles are conical. In the Polymastodontidæ they are flattened. The transition from

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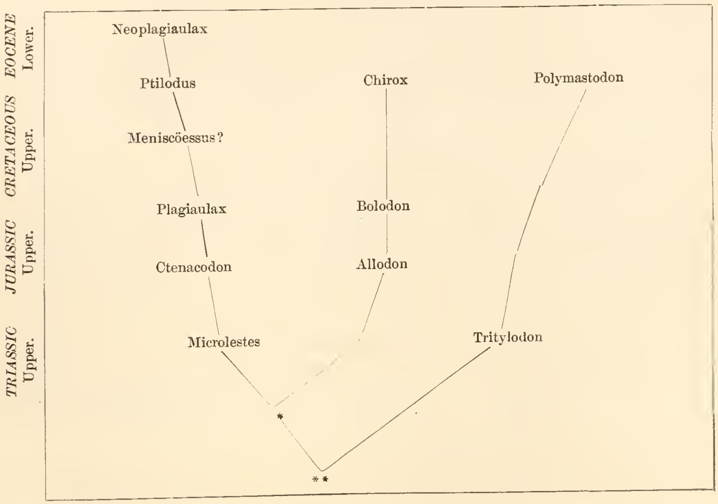
[1] Lydekker mentions (Cat. of Foss. Mamm., Part V., p. 195, footnote), that Lemoine describes two upper incisors and a canine in *Neoplagiaulax*. I have not met with this description as yet.

[2] "The Mechanical Causes of the Origin of the Dentition of the Rodentia." American Naturalist, January, 1888, p. 12.

the two to three row types is beautifully shown in *Chirox* (p. 219). The molars of *Stereognathus*, which has provisionally been placed in this group, show an antero-posterior crescentic disposition, very similar to that observed in the transverse crescents of the primitive Selenodont Artiodactyle molars. The same is true of the Meniscoëssus molars. The former is the only genus in which three rows of tubercles are found in the lower jaw.

We can form no adequate conjecture as to the origin of the multitubercular molars. If the quadritubercular type, in other lines of descent, sprang from the single cone, there is no reason why the same should not have been the case here. There is some ground for this surmise, in the evolution of the multitubercular from the quadritubercular molars among the Plagiaulacidæ, and the transition from the tritubercular to quadritubercular premolars of the Bolodontidæ.

The reduction of the molars was evidently postero-anterior. The typical or stem dentition was probably i 3, c ?, p 4, m 6. The hypothetical relationships of these families may be expressed in this diagram. The Plagiaulacidæ and Bolodontidæ seem to have diverged at an early period from one stem and the Tritylodontidæ and Polymastodontidæ from another. It is possible that the last two families were upon the same line.



**Hypothetical.

IV.—THE ZOÖLOGICAL POSITION OF THE MESOZOIC MAMMALIA.

A. FIRST GROUP.

While the Multituberculata are widely separated from the mammals of the second group, they are so closely related to each other by the unique structural and functional adaptations of the dentition, that the discovery in one genus of a single taxonomic character, which is distinctive, will probably determine their position either with the Monotremata or Marsupialia or in an independent order; no character of such importance is known at present. Their relation to the *Marsupialia* was proposed by Falconer[1], accepted by Owen[2], Cope[3] and Marsh[4], and in fact has not been questioned until Poulton's[5] recent discovery of multitubercular teeth in *Ornithorhynchus*, which has led Cope to suggest their reference to the Monotremata.[6]

Falconer and Owen referred *Plagiaulax* to the Diprotodontia, principally on the following grounds: the similarity of the premolars and incisors to those of *Hypsiprymnus*, and the slight inflection of the lower inner margin of the ramus. Cope separated the Multituberculata as a sub-order from the Diprotodontia, but gave additional grounds for their reference to the Marsupialia, from his observations upon the skeleton of *Polymastodon*, as follows: the inflection of the angle of the jaw and the position of the dental foramen at the apex of the masseteric fossa; the astragalus is without trochlea and bears a large facet for the cuboid bone, with a narrow head and navicular face convex in a vertical direction only, a form much like that of *Halmaturus*. The condyle of the humerus has a double articular facet, and a strong and thick intertrochlear ridge in front. The distal end of the humerus of *Meniscoëssus* displays the same characters. In the skull of *Tritylodon*, we observe the marsupial affinities in the terminal position of the anterior nares, in the junction of malars and lachrymals and the exclusion of the premaxillaries from the frontals.

The writer has provisionally adopted Cope's sub-order in this memoir.[7] Lydekker[8] recently has provisionally described this group as primitive Diprotodonts. It must be admitted first, that the sum total of osteological evidence for general marsupial relationship is not of a very satisfactory character, and, second, that a close study of the dentition necessitates the separation of this group from their supposed special relation to the Diprotodonts.

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1 "Description of two species of Plagiaulax, &c." Quart. Journ. Geol. Soc., August. 1857. Palæontol, Memoirs, Vol. 11, p. 422.

2 "Mesozoic Mammalia," p. 88.

3 "Tertiary Marsupialia," Am. Nat., 1884, p. 688. Also, "Tertiary Vertebrata," Hayden's Surv., 1884, p. 689.

4 "American Jurassic Mammals," loc. cit., p. 345.

5 Roy. Soc. Proceedings, February, 1888.

6 "American Naturalist," March, 1888, p. 259.

7 Proc. Phila. Acad., June, 1887. Also American Naturalist, March, 1888, p. 232. This Memoir p. 213.

8 Cat. Foss. Mamm., Part V, p. 195.

The longitudinal arrangement of the conical tubercles in two or more rows upon the molars has no parallel among the Diprotodonts. The only approach to it is in *Myrmecobius*. The most striking dental feature of both these groups is the hypertrophy of a pair of incisors in each jaw; but so far as a close comparison of these incisors in the fossil and recent forms is possible, it shows that these teeth in the two groups are neither homologous nor homodynamous, although they bear a superficial analogy. As regards homology; in all the quaternary and recent Diprotodonts it is the *median* incisor which is hypertrophied, whereas in the mesozoic genera, upon grounds given above, the *second* incisor, or rather one of the lateral incisors was hypertrophied, while the median incisor was atrophied or suppressed. As regards homodynamy; the nearly universal characteristic among the multituberculates of a fore and aft grinding motion between the alternating rows of tubercles, was associated with the rapid reduction of the upper and lower incisors to one pair. In contrast with this disposition, the recent Diprotodonts present, for the most part, three upper incisors; while the extreme reduction and fore and aft grinding motion, are confined to a single family, the *Phascolomyidæ*, in which alone the incisor function is like that in the Rodents.

The relationship to the Monotremes is possible. As observed by Cope, Poulton's description[1] of the true teeth in the young *Ornithorhynchus paradoxus* at once reminds us of the dentition of *Plagiaulax*. "The anterior tooth of the upper jaw was long, narrow and simple as compared with the others; it was very fully developed, containing completely formed dentine and enamel, and its apex was nearly in contact with the lower surface of the oral epthelium. All the other teeth were broad and large, those of the upper jaw possessing two chief cusps on the inner side of the crown, and three or four small cusps on the outer side, while this arrangement was reversed in the lower jaw." According to this, the two chief cusps are upon the outer side of the lower jaw, whereas in the Plagiaulax series (fig. 7, text) they are invariably upon the inner side; this fact lessens the degree of resemblance, but there is little question that these teeth are of the rare multituberculate type, and this discovery has an important bearing upon the problem. The humerus of *Ornithorhynchus* and *Echidna* presents a single convexity for the radius and ulna, the proximal face of the radius being placed immediately in front of the ulna. The multituberculate humerus (*Polymastodon, Meniscoëssus*) presented a double convexity; the ulna and radius were placed transversely. In some *Ornithorhynchus* specimens there is a stout intertrochlear ridge, as in the above multituberculates.

Such comparisons leave no certain result. The separation of these genera from the Diprotodonts, justifies the prediction, as a result of future discovery, that the Multituberculata will prove to be the last representatives of a very ancient phylum

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[1] Proc. Roy. Society, Feb. 9th, 1888, p. 353. Abstract in *Nature*, Feb. 16th, 1888, p. 383. See Appendix.

which reached too great a degree of specialization and dental reduction[1] at the close of the Cretaceous to survive or leave descendants in the recent period. Whether they are to be considered as a branch of the monotreme or of the marsupial stock is an unsettled question.

B. Second Group.

As we have seen upon pages 212 and 223, the mammals of this group are so distinct from the Multituberculata that their zoölogical position must be considered separately, and, unlike this order, they conform so little to a common type that when the approximate systematic position of one genus or family has been determined, it by no means settles the question in regard to the remainder. Do they belong to a distinct order? Are they exclusively Marsupials or Insectivores, or do they stand in ancestral lines leading to each of these orders? These are the three forms of the problem, which are conditioned by the wider question whether the Placentalia have ever passed through the marsupial stage, with a peculiar yolk-sac placenta[2] and restricted milk dentition.

In the conclusion of his memoir (page 113), Professor Owen expressed his views as follows: "Among these initial forms of *Marsupialia* we may see in *Amphitherium* the prototype of *Myrmecobius ; Stylodon* has its analogue in *Chrysochloris ; Peralestes* has culminated in *Sarcophilus; Triconodon* in *Thylacinus; Plagiaulax* is to *Thylacole* what the weasel is to the lion." On page 111, he suggested that we found here also among those genera, in which marsupial characters were less clear, early forms of modern Insectivora, but gave no specific grounds for this view. The prevailing opinion among palæontologists that the jurassic mammalia are all to be classed with the Marsupials, has been recently adopted by Lydekker.[3] In reference to the polyprotodont genera he writes: "The majority of which appear so nearly related to existing Marsupials that it has been a question whether some of them should not be included in the modern families." In proposing the order *Pantotheria*, Marsh in 1880[4] and again in 1887,[5] expressed the diverse opinion that the mesozoic mammalia cannot be satisfactorily placed in any of the recent orders: "With a few exceptions the mesozoic mammals best preserved are manifestly low generalized forms, without any distinctive marsupial characters. Many of them show features that point more directly to the Insectivores, and present evidence based on specimens alone would transfer them to the latter group if they are to be retained in any modern order."

[1] It is a well known generalization that rapid specialization and reduction, in most cases, leads to extinction.

[2] Osborn, "The Fœtal Membranes of the Marsupials: The Yolk-sac Placenta in Didelphys." *Journ of Morph.*, Vol. 1, 1887, No. 2, p. 373.

[3] 'Cat. Foss. Mamm.,' Part V, p. ix.

[4] *Am. Jour. Sc.*, Vol. XX, p. 239, 1880.

[5] *Am. Jour. Sc.*, Vol. XXXIII, p. 344, 1887.

The grouping of all these genera in one distinct order is, however, impracticable; first, because the members of at least one family present distinctively marsupial characters; second, it is impossible, with our present knowledge, to assign a single character of ordinal value which is universal; third, as to the minor question of systematic arrangement, there is no precedent for including in one order, such types as *Kurtodon, Stylacodon* and *Triconodon*, in which the teeth are as diverse as in the recent Rodentia, Insectivora and Carnivora. If distinct from the Marsupialia, the mesozoic mammals certainly represent an equivalent subdivision of the *Metatheria.* Of the nine characters assigned to the *Pantotheria* by Marsh, only two rest upon actual observation through the entire series, viz.: the mylohyoid groove and the unankylosed symphysis. The latter is not distinctive. The mylohyoid groove, is shown by data collected in the Appendix, to have little taxonomic value. The character, (1) "cerebral hemispheres smooth," was undoubtedly true of all mammals of this period, and can be actually observed in one of the unique Yale College specimens. Each of the remaining characters excludes one and, in some cases, several genera: (2) Teeth exceeding, or equaling, the normal number, 44. (3) Premolars and molars imperfectly differentiated. (4) Canine teeth with bifid or grooved fangs. (7) Angle of lower jaw without distinct inflection. (8) Angle of jaw near or below horizon of teeth. (9) Condyle vertical or round, not transverse.[1]

The supposition that *all* these mammals can be placed in the Marsupialia is equally untenable, or, at least, it may be said to rest upon no foundation whatever. It has been the fate of numerous primitive mammals, at the period of their discovery, to be placed without much reason or question in this order. The *Creodonta* is a conspicuous instance. This tendency is a remnant of the old doctrine that all primitive mammals were Marsupials, which is opposed on numerous grounds by the more recent view that the Marsupials and Placentals were branches from a common stem[2]; in fact the peculiar reduction and succession of the teeth[3] and mode of placentation exclude the derivation of the Placentals from the Marsupials, and we now have abundant evidence that these eccentricities of the marsupial dentition were fully developed as early as the later Mesozoic period. Does this not indicate that the separation of these two stocks had already taken place? Where are we to look for

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[1] (2) Excludes *Paurodon.* (3) In all the genera known to the writer, the premolars, where present, are well differentiated from the molars. (4) Excludes *Phascolotherium* and *Amblotherium.* (7) Excludes *Triconodon* in some of its species, *T. ferox.* (8) Excludes *Amblotherium, Stylodon* and *Amphitylus.* (9) Excludes *Phascolotherium* and *Triconodon.*

[2] See Huxley, "On the Arrangement of the Mammalia," Proc. Zool. Soc., Dec. 14, 1880, p. 649. The systematic portion of this valuable article was partly anticipated by Gill, in his "Arrangement of the Families and Sub-Families of Mammals," Smithson. Contrib., Vol. XI, 1874. Following Gill's line of suggestion, Huxley proposed the term *Prototheria* for the representatives of this stem stage.

[3] Oldfield Thomas, in his recent memoir, shows that the consideration of the reduction and succession of the teeth alone forces us to the same conclusion.

the ancestors of the rich fauna of placentals found in the Puerco, if not in the known Jurassic and as yet unknown Cretaceous mammals? The probable features of the dentition of the stem type have already been outlined from a comparison of the Mesozoic genera, on page 247. The jaw had an unankylosed symphysis, a mylohyoid groove and a distinct coronoid, angle and condyle.

We may now consider the limited evidence we have which bears upon the zoological relations of these mammals. The *Protodonta* are considered as a distinct order and are not included in this discussion because nothing is known of their contemporary or succeeding fauna.

Relations to the Marsupialia.

The only distinctive features of the modern marsupial mandible and dentition are the inflection of the angle and the peculiar reduction and succession of the teeth. But we find the angle is not inflected in *Tarsipes* nor in some species of *Peratherium*,[1] showing that this is not an essential marsupial character. The condyle and angle vary in position and relation directly according to the function of the jaw. They are low and confluent in the carnivorous forms, lofty and separate in the insectivorous forms. A mylohyoid groove is occasionally developed; it was described by Owen in *Myrmecobius*,[2] which is also multidentate, the teeth numbering 54, (i $\frac{4}{3}$, c $\frac{1}{1}$, pm $\frac{3}{3}$, m $\frac{5}{6}$). There are in most genera four molars and never more than three premolars. Oldfield Thomas has recently confirmed Flower's hypothesis that the Marsupials have lost one premolar, enabling us to homologize this with the placental series. The canine is bifanged in *Chœropus* and occasionally in *Perameles*. Four lower incisors are sometimes developed, *e. g.*, *Didelphys*, although the typical number is three.

Unmistakable marsupial characteristics are found among the *Triconodontidæ* and *Amphitheriidæ*. The mylohyoid groove is always present. The angle unfortunately is rarely preserved; so far as known, it is not inflected in the latter family. It is distinctly inflected and shelf-like in *Phascolotherium* and *Spalacotherium*, and fully marsupial in *Triconodon*. The primitive number of incisors is four, but, as shown upon page 248 is reduced to three in the carnivorous series, by the loss of *i* 4. The canines are bifanged in the greater number of genera. The premolars are almost constantly four in number, and their mode of reduction and succession is strikingly marsupial. As shown upon page 247 the *Amphitheriidæ* lose the second premolar, which is by no means a common mode of reduction, yet it corresponds with what has

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[1] Fide Cope, "Tertiary Marsupialia," p. 687, *Peratherium fugax*. Schlosser, on the other hand, finds the angle inflected in all the European species.

[2] This observation appears to have been a mistake. See Appendix.

probably occurred in the ancestors of the *Dasyuridæ*.[1] In the *Triconodontidæ*, on the other hand, p_1 was apparently suppressed. In each case the reduction resulted in the typical marsupial number. The mode of premolar milk succession in *Triconodon* was, so far as observed, typically marsupial.

We thus find in these two families several characters which are shared by one or other of the Marsupials, and others which are exclusively Marsupial, leaving no reasonable doubt as to their relationship. The evidence in the case of the *Triconodontidæ* is, however, much the strongest, and, as Professor Owen pointed out, they bear further a family likeness to the *Dasyuridæ*. *Triconodon* resembles *Thylacinus* in the shape of the mandible, in the triconodont type of inferior molars, in the very late appearance of the fourth true molar, but lacks the internal heel of the superior molars. The position of the *Peralestidæ* is doubtful, turning largely upon our interpretation of the homologies of the molar cusps. The molars of *Peraspalax* are very similar to those of *Didelphys*, as seen upon the inner surface, but lack the apparent derivation from the tritubercular type. As observed above, in discussing the Multituberculata, we must distinguish carefully between real and superficial resemblances. This obtains also in the following comparison.

The discovery of the *Kurtodon* molar pattern apparently adds another mesozoic marsupial prototype in its likeness to that of *Phascolomys* (Plate IX, fig. 15.) In the mesozoic genus the premolars are rudimentary and separate; in the recent genus all but one have disappeared. In both genera the upper molars are compactly placed and present an outward curvature. The *Phascolomys* molar resembles two *Kurtodon* molars placed side by side, as the columnar crowns present an external groove *g*, and two outward opening Vs instead of one; the enamel *e* at the sides of the V is raised, and the intervening valley of dentine *d* is bisected by a faint ridge *e′* which apparently is the bottom of a superficial fold of enamel. In both genera the last premolar is molariform. The remaining premolars are small in *Kurtodon*, and have disappeared in *Phascolomys*. An important difference is the large canine[2] in *Kurtodon vs.* the rodent-like median incisor of the recent genus, which seems to show that these genera do not belong upon the same line.

To conclude, the *Triconodontidæ* were undoubtedly in the marsupial line; the *Amphitheriidæ* were probably Marsupials and the *Kurtodontidæ* were possibly so; while there is no means of deciding in regard to the *Peralestidæ*. No definite subordinal character can be assigned, but in view of the retention of several primitive

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[1] See Oldfield Thomas, "On the Homologies and Succession of the Teeth in the Dasyuridæ, etc.," *Phil. Trans.*, April 28th, 1887, p. 443. In this valuable memoir, the author reaches the conclusion that pm_2, was probably the tooth which was suppressed in all the Polyprotodonts, and i_4 of the incisor series. The generalized marsupial formula is given as i 5 p 4 m 4. The apparent reduction of p_1 in the *Triconodontidæ*, does not support the author's hypothesis that p_2 was uniformly suppressed in the Marsupials.

[2] It is possible that this tooth although caniniform may prove to be an incisor.

features and of their ancestral position, these mammals may be distinguished from the recent Marsupials as the sub-order *Prodidelphia*.

Relations to the Insectivora.

It has been shown that the *Stylacodontidæ* have the dentition and jaw peculiarly adapted to an insectivorous diet (p. 235). They apparently present the *tubercular-sectorial* molar pattern, a much more recent type than that attained in any other family. The nearest point of contact of this pattern is with *Spalacotherium*, a genus widely separated from this family by its functional adaptation. The reduction of the premolars and molars differs from that observed in other families (p. 248). The dentition is unique in combining the rapid progression of the molar pattern with the conservative retention of the primitive formula. All these facts go to support the assumption that this family is on a distinct line of descent and that it separated from the line of the *Triconodontidæ*, the only family to which in its molar pattern it is in any degree allied, at a very distant period. This is in the nature of demonstration that the marsupial affinity of *Triconodon* does not necessarily affect the position of the *Stylacodontidæ*. Again, omitting the tubercular-sectorial molar which leads into both the marsupial and placental series, there is not a single marsupial characteristic in the dentition or mandible of this family. Nor does any fossil or recent Marsupial present tritubercular molars of the *Stylacodon* type.

The researches of Huxley,[1] Parker,[2] Cope and others all point to the early origin and central position of the Insectivora. We have abundant anatomical and embryological evidence for the hypothesis of a primitive point of contact of this order with the Marsupials, to which additional palæontological evidence can now be brought forward.

Among the Insectivora we find traces of the primitive mammalian dentition in the retention of the simple tritubercular type and frequent occurrence of the bifanged canine, as in *Centetes*, *Talpa* and *Gymnura*. Some of the specializations of this dentition have been enumerated recently in Schlosser's exhaustive memoir.[3] These are, the chisel-shaped incisors and elongation of the central pair; the occasional metamorphosis of the canine into an incisor as seen in *Talpa*; the enlargement and complication of the posterior premolars, beginning with the last and extending forwards; the reduction of

[1] Op. cit., p. 657.

[2] "On the Structure and Development of the Skull in the Mammalia, Part III, Insectivora." Phil. Trans. Roy. Soc., Part. I, 1885, p. 268. "One thing can be done, even now, with the present fragmentary knowledge of the structure and development of the Insectivorous types—we can assure ourselves that these types are immediately above the Marsupials * * and that the Insectivora are more or less transformed modifications of what is characteristic of the Marsupials."

[3] "Die Affen, Lemuren, Cheiropteren, Insectivoren, Marsupialier, Creodonten und Carnivoren des Europäischen Tertiärs." Alfred Hölder, Wien, 1887.

the first premolar and frequent atrophy of p_2; the occasional prismatic elongation of the molars, (*Chrysochloris*).

All the above peculiarities are observed in different members of the *Stylacodontidæ*, some of which approach the typical insectivorous structure much more closely than others. The peculiar feature of some genera is the separation and prismatic elevation of the crowns in a triangular section, as in *Chrysochloris*, so that when the upper and lower series are brought together they form alternating triangles, with the bases turned outwards in the upper and inwards in the lower molars (*Asthenodon*). The styliform elongation of the molar crowns is very extreme in some of the British Museum specimens of *Stylacodon* (No. 47,758). The procumbent incisiform canines and chisel-shaped incisors are seen in Owen's type of *Stylodon*. The postero-internal cusp of *Dryolestes* is also found in *Calcochloris*. Altogether, while admitting the risk of systematic determination upon the basis of such analogies, we cannot deny that there is far more ground at present for placing the *Stylacodontidæ* in or near the line of the Insectivora,[1] than in any other order.

No distinctive characters can be assigned at present to the *Insectivora primitiva* except the primitive formula, to distinguish them from the recent Insectivora, and the tritubercular molars, to distinguish them from the other Jurassic groups.

The above general phylogenetic conclusions may be summarized as follows:

I. That the Jurassic members of the Second Group, although not forming a single distinct order, bear marks of comparatively recent origin from a common stem.

II. They subdivide into at least two larger series, including six or more families, which respectively lead to the Marsupialia and to the Placentalia, possibly to some of the existing families of the same.

III. These series, as found at this period, have considerably diverged from each other and have assumed structural modifications which are at present peculiar to the Marsupialia and Insectivora.

In addition to the acknowledgments made in the introduction, I wish in closing to express my indebtedness to Professor W. H. Flower, for his friendly aid extended to me while working in the British Museum; to Professor S. F. Clarke, of Williams College, for the loan of material; to Professor O. C. Marsh, for the supply of clichés of his woodcuts. All the text illustrations, with the exception of these cuts, are the work of Mr. Rudolph Weber. I may call attention to the fact that since my first studies and sketches of the English types were made, I have been unable to re-examine

[1] Schlosser (op. cit., p. 137) leaves the phylogenetic position of the *Chrysochloriidæ* in some doubt. Their limited distribution, unique dentition and anatomy, possibly denote that they represent a low persistent type.

According to Peters, the mammary glands of the Cape mole (*Chrysochloris*) are without teats. Monats. Akad. Wiss. Berlin, 1865.

this material, and have thus been obliged to leave several mooted points in doubt. There are some discrepancies between the earlier and later pages of this memoir, owing to its having occupied nearly nine months in passing through the press. This has been in spite of the kind efforts of Dr. Edward J. Nolan, Secretary of the Academy, to hurry the matter forward. The delay has, however, given me the benefit, in the latter portion of the work, of the valuable recent contributions of Lydekker, Oldfield Thomas, Schlosser and Cope upon this and related subjects.

PRINCETON, July, 1888.

APPENDIX.

1. THE MYLOHYOID GROOVE IN THE MESOZOIC AND RECENT MAMMALIA. Professor Owen described and figured a mylohyoid groove in *Myrmecobius* and, as it is universally present in the Mesozoic mammals of the Second Group, much stress has been laid upon it in classification. Dr. Otto Meyer recently called the writer's attention to the fact that the groove in the *Myrmecobius* jaw is not similar to that in the Mesozoic mammals, and in any case questioned its homology and taxonomic importance. This led me to examine the lower jaws of all the marsupials and primates in the collections of Princeton, the Philadelphia Academy and Yale College, with the following results: 1° A groove similar to the mylohyoid of the human jaw is frequently, but not constantly, present among the primates; in *Gorilla*, strongly developed; *Troglodytes*, wanting; *Simia*, faintly developed; *Cynocephalus*, very distinct. It varies with age and somewhat within the species. 2° Among the Marsupials this groove is even more variable, never very distinct, constantly subject to individual variation: *Myrmecobius*, wanting in the two specimens in the Yale Museum, also in the numerous specimens in the British Museum, as kindly observed for me by Mr. Oldfield Thomas; *Phascolomys*, present in only one-half the specimens examined; faintly seen in some specimens of *Didelphys* and *Dasypus*; *Dasyurus*, *Thylacinus* and *Bettongia*, absent in all the specimens examined. 3° In all the above cases this groove extends obliquely downwards and forwards from the orifice of the dental canal; there is thus little doubt that it lodges the mylohyoid nerve or artery, which branch from the dental pair at this orifice. 4° In all the Mesozoic mammals, in which the groove has been observed, it invariably extends from near the dental foramen for a greater or less distance along the inner face of the ramus, sometimes descending rapidly to the lower border (*Phascolotherium*), sometimes reaching the symphysis (*Amblotherium*). From its constant relation to the dental canal and variable development, there is little room for doubt that it lodged either the mylohyoid nerve or artery; at least there is no ground for any other supposition. 5° *Dromotherium* presents an exception; the orifice of the dental canal is apparently placed more anteriorly; the anterior border of the pterygoid fossa is not clearly defined as in

all the Jurassic genera, but gradually closes into a long, narrowing groove, which suddenly terminates in the middle of the ramus in a foramen beneath the last premolariform tooth. It appears as if the inferior dental artery may have lodged in this groove and entered the jaw at this anterior point. From these data, I see no reason for altering Professor Owen's designation of this as the "mylohyoid groove," but strong reasons for not attaching great taxonomic value to its presence or absence.

2. Synonymy.

For *Diplocynodon* read *Dicrocynodon.* Professor Marsh in a letter to myself, dated April, 1888, has substituted the latter name, Mr. Lydekker having called attention to the fact that the former is preoccupied by Pomel. Bul. Soc. Geol., 1846, t. III, p. 372.

For *Athrodon* read *Kurtodon*; see page 208 footnote.

For *Stylodon* read *Stylacodon*; see page 236 footnote. It is possible that a new generic name may be required for the English type of *Stylodon*, if the American types prove distinct from it.

For *Triglyphus* read *Tritylodon.* Mr. Lydekker (op. cit., p. 201) notes that the former name is preoccupied for a genus of Diptera. The supposed premolar, described upon page 221, probably belongs to the species *T. fraasii*, Lydekker.

Errata.

For *Dromatherium* read *Dromotherium* throughout.

Page 191, 18th line, read "*Amphitherium.*"

Page 194, 3rd line, for "genera" read "genus."

Page 213, 10th line, for "lower Triassic," read "lower Jurassic."

Page 214, 1st line and footnote, for "*Plagiaulacidæ*,[1] Marsh," read "*Plagiaulacidæ*, [1]Gill.' "[1]Smithson. Misc. Coll., 1874, p. 27."

Page 219, 13th line, 6th word, for "premolars" read "molars."

Page 220, 10th line, for "median" read "intermediate."

EXPLANATION OF PLATES VIII AND IX.

Illustrating Dr. Henry Fairfield Osborn's Memoir upon THE STRUCTURE AND CLASSIFICATION OF THE MESOZOIC MAMMALIA:—

The figures were drawn by the author with the aid of a camera,[1] insuring their accuracy of proportion and outline. They are enlarged in some cases to seven diameters, and often reversed, to bring out clearly the comparative structural details. The enlargement is not proportional to actual size. Figures 1, 3, 5, 8, 9, 10, 11, 13, 14, 15 are from single specimens; the remaining seven are *composites.*[2] Composition figures are adopted in cases where two specimens of one individual fall in reversed slabs; or where two specimens, from different individuals, agree in size and contain two or more similar teeth in common. For example, in *Bolodon,* figure 16, parts of two maxillæ were thus united, both of which showed the maxillary suture and four similar teeth behind it. In most cases, the numbers attached to the original specimens in the British Museum collection are recorded, in order to enable other investigators to confirm or disprove the composition. In preparing the drawings, some parts were naturally more fully known and certainly related to each other than others. These degrees of probability are expressed in the drawings in the following manner: (1) In cases where there is positively no reasonable doubt as to the relation of two composite specimens (as in the *Bolodon* maxilla) the parts of each are fully shaded, as if they belonged to one individual. (2) Where the outline of the teeth or jaw is ascertained from impressions left in the matrix, or where a specimen has fallen into two slabs, one showing the inner, the other the outer surface, plain contour lines are used. (3) Where the evidence is not from one of the composites, but from another specimen belonging to the same genus or species, or where the presence of a tooth is somewhat conjectural, dotted lines are employed. These rules are all illustrated in the figure of *Spalacotherium* and are adhered to in all the drawings unless it is otherwise distinctly stated.

Abbreviations. *a,* angle. *c,* condyle. *d,* dental foramen. *f,* infraorbital foramen. *m,* mylohyoid groove. *mf,* mental foramen. *s,* mandibular symphysis. *ms,* maxillo-premaxillary suture. *i, c, p, m,* dental series.

THE BRITISH MESOZOIC MAMMALS.

FIGURE 1. *Amphilestes Broderipii.* Inner surface of the left mandibular ramus, enlarged 4 diameters. Copied with slight alterations from Professor Owen's memoir, "Geological Transactions, Ser. 2, Vol. VI., 1839, Plate VI." By an error in transposing one of the molars, m_1 was omitted.

FIGURE 3. *Phascolotherium Bucklandi.* Inner surface of the right mandibular ramus, enlarged 3½ diameters. From the original specimen in the British Museum collection, with some aid from Dr. Buckland's figure, "Bridgewater Treatises, Geology and Mineralogy, Plate II."

FIGURE 4. *Triconodon ferox.* Restoration of the inner view of the mandible and of the mandibular and maxillary dentition, enlarged 3½ diameters. The main portion of the mandible and

[1] This camera is manufactured by Nachet et Fils, Rue St Severin, Paris, and is an invaluable instrument for drawing small, opaque objects.

[2] A convenient distinction may be drawn between a "composite" and a "restoration" figure. The former is the result of the combination of two specimens which have many parts in common; the latter is a combination of known parts with missing parts which are conjectured from allied forms.

lower dentition is from No. 47,775 in the British Museum collection; the tips of the first and second premolars are restored from a specimen of *T. occisor;* the canine is from a matrix impression, and the incisors from another specimen of *T. ferox* (Mes. Mamm., Pl. IV., fig. 1). The angle and condyle are drawn from another specimen of *T. ferox.* The maxillary dentition, also viewed upon the inner surface, is from Nos, 47,788 and 47,779, which have the third premolar in common.

FIGURE 5. *Triacanthodon* (Triconodon) *serrula.* The outer surface of the left mandibular ramus. Drawn from the original specimen, No. 47,763. Enlarged 3½ diameters.

FIGURE 6. *Peramus tenuirostris.* The outer surface of the left mandibular ramus, enlarged 4½ diameters. The main portion of the ramus with three molars and the last premolar is drawn from No. 47,742; the premolar crowns and symphysial portion of the ramus is from No. 47,744; these specimens have pm_6 and m_1 in common.

FIGURE 7. *Spalacotherium tricuspidens.* The inner surface of the left mandibular ramus, reversed. Enlarged 3½ diameters. The ramus and dentition as far forwards as m_1 is from No. 47,750; the remainder of the figure is from the outer view of the forward portion of the same specimen in the counterpart block of matrix. The incisors are from other specimens.

FIGURE 8. *Peralestes longirostris.* The outer surface of the right maxilla, enlarged 3½ diameters. Drawn from a single specimen. (Mes. Mamm., Plate II., fig. 3).

FIGURE 9. *Peraspalax talpoides.* The inner surface of the left mandibular ramus, enlarged 3½ diameters. Drawn from a single specimen, No 47,738. The canine and anterior premolars are shown in the matrix impressions.

FIGURE 10. *Leptocladus dubius.* The outer surface of the left mandibular ramus, enlarged 6 diameters. Drawn from a single specimen, No. 47,739.

FIGURE 11. *Amblotherium soricinum.* The right mandibular ramus, seen upon the inner surface, and enlarged 5½ diameters. This was drawn from a single specimen, No, 47,752.

FIGURE 12. *Phascolestes dubius.* A portion of the left mandibular ramus, seen upon the inner surface, and enlarged 4 diameters. Drawn from a single specimen, No. 47,741.

FIGURE 13. *Achyrodon nanus.* A portion of the right mandibular ramus, seen upon the inner surface, and enlarged 5 diameters. Drawn from a single specimen, No. 47,745.

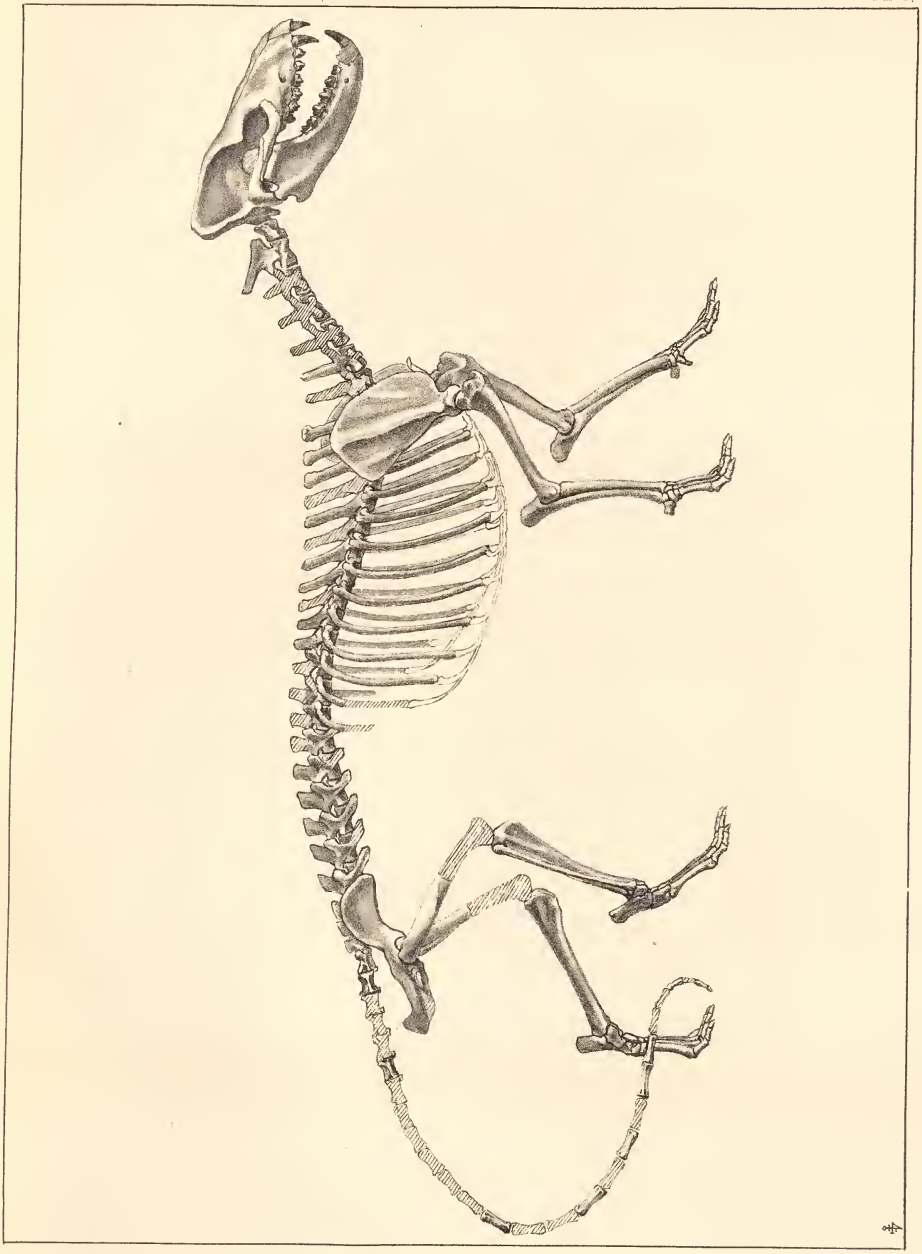
FIGURE 14. *Stylacodon pusillus.* The outer surface of the left mandibular ramus, enlarged 4½ diameters. The main portion is from No. 47,757. The coronoid and angle are from another specimen. (See Owen, Mes. Mamm., Pl. II., fig. 15).

FIGURE 15. *Kurtodon pusillus.* The inner surface of the left maxilla, enlarged 4 diameters. Drawn from a single specimen, No. 47,755. 15A represents the wearing surface of the molar crowns; *e*, the enamel encircling the crown; *e'*, the enamel ridge traversing the crown; *g*, the external groove. 15B. represents the wearing surface of a left upper molar of *Phascolomys ursinus;* letters *e*, *e'* and *g* as above; *d*, dentine between the median enamel ridge and the surface enamel.

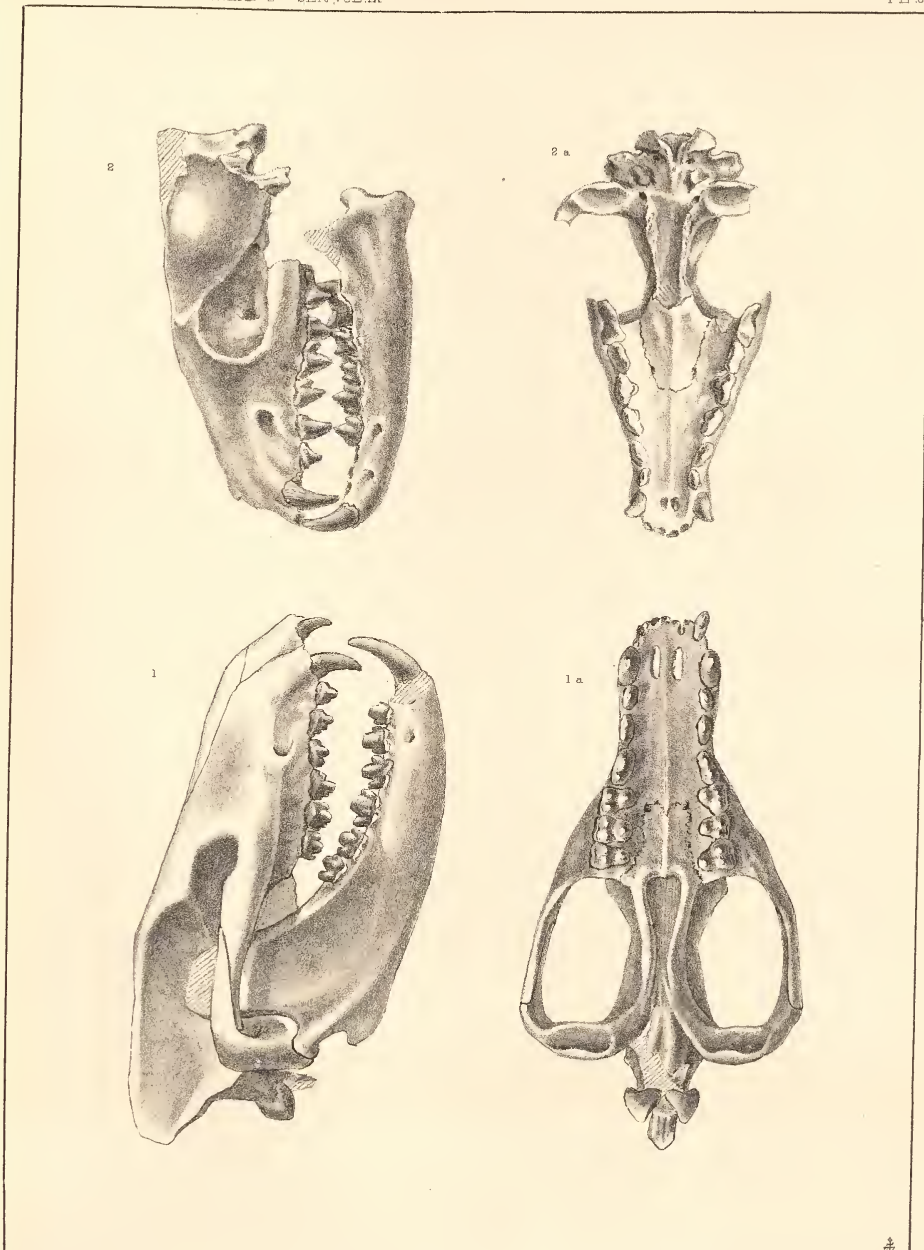
FIGURE 16. *Bolodon crassidens.* The outer surface of the right maxilla, enlarged 3½ diameters. The anterior portion is from No. 47,735; the posterior portion is from another specimen. The specimens have four teeth behind the maxillo-premaxillary suture in common. 16A wearing surface of the molar premolar-series.

AMERICAN TRIASSIC.

FIGURE 17. *Dromotherium sylvestre.* The inner surface of the left mandibular ramus, enlarged 4½ diameters. Drawn from a single specimen in the Museum of Williams College.



MESONYX OBTUSIDENS.



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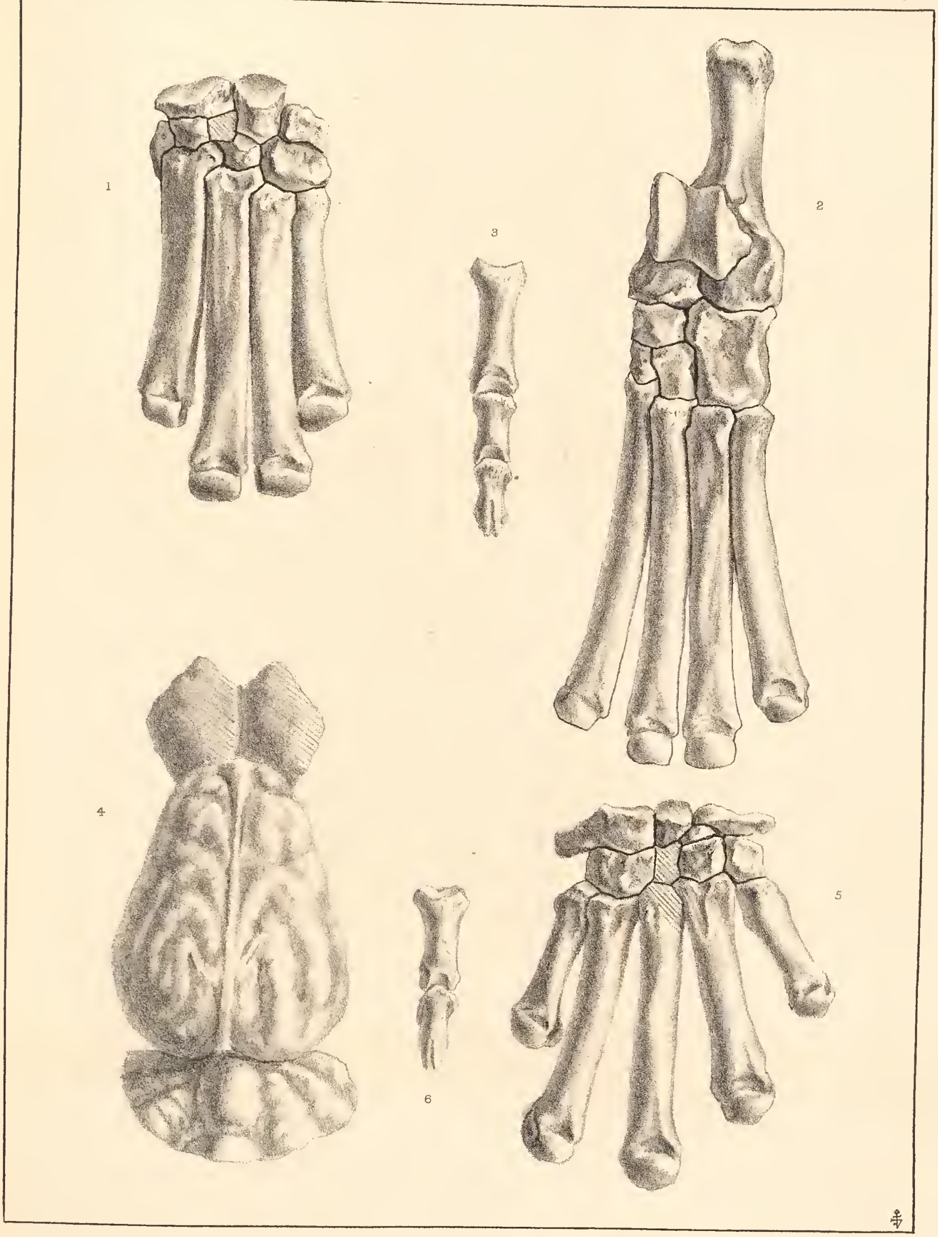
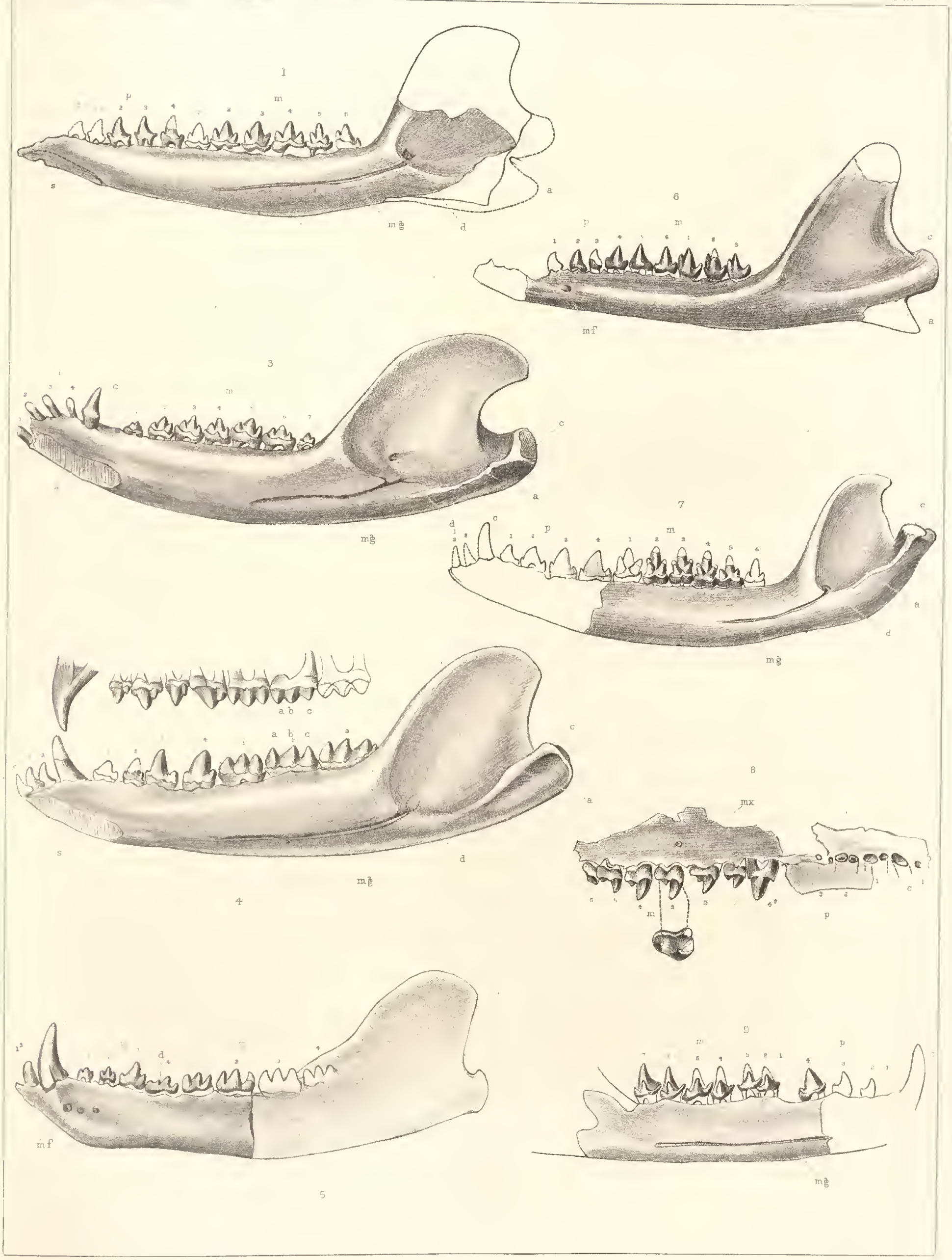
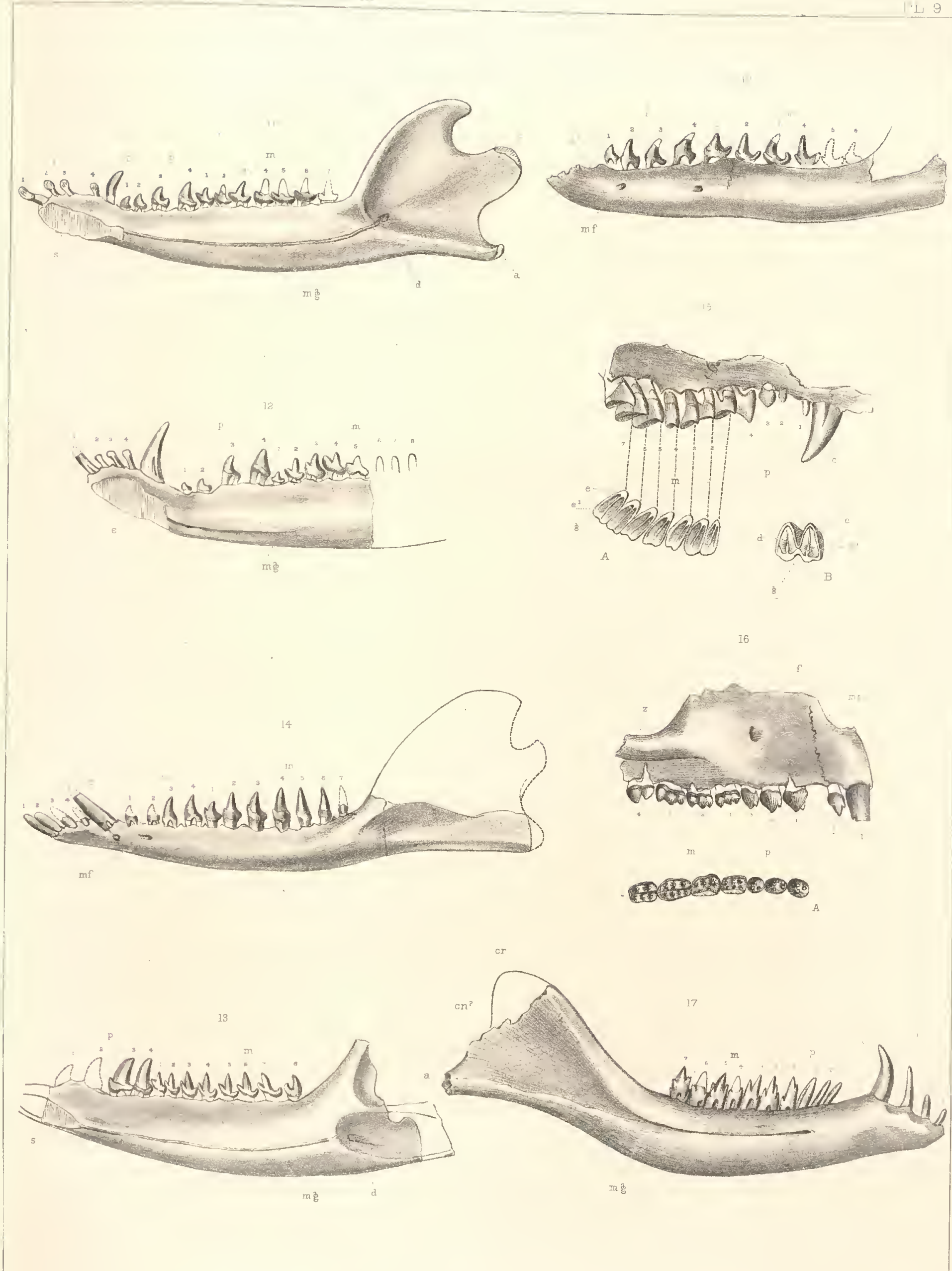


1-3. MESONYX 4-6 HYÆNODON.



1 AMPHILESTES 3. PHASCOLOTHERIUM 4 TRICONODON. 5. TRIACANTHODON 6 PERAMUS
7 SPALACOTHERIUM. 8. PERALESTES 9 PERASPALAX.



10 LEPTOCLADUS 11. AMBLOTHERIUM. 12 PHASCOLESTES 13. ACHYRODON. 14. STYLODON
15. KURTODON. 16. BOLODON. 17. DROMATHERIUM.

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1892.

A MEMOIR UPON THE GENUS PALÆOSYOPS LEIDY, AND ITS ALLIES.

By Charles Earle.

The following memoir is the result of my studies upon the collections of specimens belonging to the genus *Palæosyops* in the Museum of the Academy of Natural Sciences of Philadelphia, in the E. M. Museum of Geology and Archæology of Princeton College, in the collection of Professor E. D. Cope, and upon some of the specimens in the Yale College Museum.

The association of the renowned name of the late Dr. Joseph Leidy with this genus has made these investigations appear of especial interest at the present time. I am greatly indebted to the authorities of the Academy for their liberality in placing in my hands the large and very valuable collection of Palæosyops material which is deposited in the Museum of that historic institution. This collection is especially valuable as it contains many of the original type specimens of *Palæosyops*, from which Leidy first gave to the scientific world the knowledge of the existence of these animals, and which later, in 1873, he fully described in his "Extinct Vertebrate Fauna of the West."

Since Leidy in 1870 described the genus *Palæosyops* from a few scattered fragments of teeth which were found at Church Buttes, Wyoming, a great advance has been made in the palæontological history of this and allied genera.

During the whole course of this investigation, I was fortunate enough to be situated in Princeton, and through the kindness of Professors Scott and Osborn, I had access to the large collections of Palæosyops material which had been made by their western expeditions. Among the numerous exploring parties that have visited the Bridger Beds, none were more successful than those sent out by Princeton College, under the leadership of Professors Scott and Osborn. Four parties in all have been sent out by Princeton to these beds, with the result that the collection in the Princeton Museum of material referable to the genera *Palæosyops*, *Limnohyops* and *Telmatotherium* is one of the most complete in this country. It is to this collection that I am chiefly indebted.

Like all palæontological investigators, I have felt the want of more complete individual material to corroborate some of my identifications. In a few cases the parts were found widely scattered. In some cases I have placed parts of the skeleton under a certain genus, where the bones were not associated with any teeth, and consequently the reference was partly conjectural. This applies particularly to my determinations under the genus *Limnohyops*, the skeleton of which has been so little known, although I have here endeavored to add something to the morphology of this interesting form. Most of my identifications will, I think, stand. There is no doubt as to the structure of the type species. I refer to the fine skeleton of *Palæosyops paludosus*, with teeth, found in the Princeton Collection.

With such limitations it is clearly impossible to write a final memoir upon this genus. My object has been rather to break the way, to clear up the synonyms, to distinguish the different types, and to throw as much light as possible upon the morphology and the variations in dental and skeletal structure.

The reader will find the phylogenetic part of this work rather crude. Owing to the present lack of material, I am unable to fill in the gaps, and offer the scheme at the end of this memoir as a preliminary basis for further observations.

It is with the greatest satisfaction and pleasure that I take this opportunity to thank my friend Dr. Henry F. Osborn, now of Columbia College, who, upon my return from Germany in the fall of 1889, invited me to come to Princeton, and suggested my taking up this investigation. His kindly advice and many valuable suggestions have been a constant stimulus to me throughout the course of my work. I am also indebted to Prof. Scott for having given me the aid of his valuable criticism in many cases. Mr. Rudolph Weber has prepared the drawings for this memoir, and they are up to his usual fine standard of work. In conclusion I wish to thank Dr. Edw. J. Nolan of the Academy of Natural Sciences of Philadelphia for the trouble he has taken in connection with this memoir.

Introduction.

Previous Literature.—The literature on the sub-family *Palæosyopinæ* is very limited, comparatively few authors having worked upon this group of fossil animals. Among the American palæontologists who have worked upon *Palæosyops*, we must first mention Professor Leidy. He states in the preface to his work "The Extinct Vertebrate Fauna of the Western Territories," that his time had been so much taken up with professional engagements, that he had not been able to study the material described in the above mentioned work as thoroughly as it should have been, and concludes that the results are not as complete as he would like to have had them. I find on carefully studying his original material and comparing the same with his descriptions, that there is some confusion in his work, and a number of slips in regard to the specific relations of the forms described.

Nomenclature and Synonyms.—In my preliminary paper I attempted to clear up the nomenclature and the specific relations of the species included in this subfamily, and I shall include this portion of my former paper in this for reference.

Cope, in his "Tertiary Vertebrata," has shown the relation of the nomenclature of *Palæosyops* and *Limnohyus* proposed by Marsh and Leidy, and there is no question as to Leidy's priority. Leidy described the genus *Palæosyops* three months before Marsh published his preliminary notice, in which he describes his *Palæosyops laticeps*.

Cope did not attempt to determine Leidy's original types, from which the genus and species *Palæosyops paludosus* were first indicated. After studying Leidy's original specimens, now in the National Museum, which he described,[1] and which later he figured[2], I am convinced that they belong to the large species of *Palæosyops*: that which Leidy subsequently named *P. major*. Second, that the smaller forms later referred by Leidy to *P. paludosus* were quite distinct from his types of this species. Therefore, as the original specimens were called *P. paludosus*, and as they were identical with a form which he later called *P. major*, the latter name is a synonym and must drop out. As Leidy's name *P. major* was very convenient in designating the relative size of the two species, we propose to call the smaller form *Palæosyops minor*=the *P. paludosus*, according to the later use of Leidy and others.

I may also add that Cope's *P. lævidens* is a different form from this smaller species of Leidy, so that Cope's specific name cannot be used for it.

Cope[3] accepts Marsh's statement that the original specimens figured by Leidy belong to *Limnohyus*. This is, I think, an error, as the teeth are much larger and correspond in every respect with Leidy's *P. major*. Marsh's statement that the teeth of his *P. laticeps* have the same general structure as those of Leidy's smaller species—namely his *P. paludosus*, is also incorrect. I have examined both types, and I shall show later that the two forms are quite distinct—one approaching the *Telmatotherium* form of molar, the other type being more like the typical molar found in *P. paludosus*. Marsh's type of his genus *Telmatotherium*[4] agrees in all particulars with the type of Scott and Osborn's *Leurocephalus*,[5] so that the latter genus must become a synonym of *Telmatotherium*. I retain Scott and Osborn's species *T.* (*L.*) *cultridens*, as a good species, and it has very interesting characters which place it rather lower in the scale than the *T. validus* of Marsh. The skull figured by Scott and Osborn in their report for 1877 as *P. paludosus*, should be referred to Marsh's genus *Limnohyops*. Its general form is very different from *Palæosyops*, as will be shown later. After carefully considering the matter of uniting the various genera into one, I am of the opinion that *Telmatotherium* may be retained, and that *Lymnohyus*, or as it is now called, *Lymnohyops*, should not have a generic value equal to that of *Telmatotherium*.

The type specimen of the genus *Limnohyops* is very closely related to that of *Palæosyops* in the teeth structure, and we have good reasons for supposing that the presence of the hypocone on the last superior molar is a transition character, which is not available for generic definition. The presence of a rudimentary hypocone on the last superior molar of *Palæosyops paludosus* is not an uncommon occurrence. The premaxillary regions of *Limnohyops* and *Palæosyops* are identical, although the skull contours are very different. The generic reference of Leidy's smaller species

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[1]Proc. Acad. Nat. Sci. Phil. 1870, p. 113.

[2]U. S. Geol. Survey of the Ter., Vol. 1, 1873, Plate V, fig. 5, and Pl. XXIII, figs. 3–6.

[3]Tertiary Vertebrata, p. 698.

[4]Am. Jour. Science and Arts, Vol. IV, pub. July 22nd, 1872.

[5]E. M. Museum Bulletin. No. 1, Report Princeton Scientific Expedition, Sept. 7th, 1878.

of *Palæosyops*, our *P. minor*, is uncertain, very little being known of the skull or of the limb bones. The characters of the molars (see his Pl. IV, figs. 3–6) are closely similar to those of *Telmatotherium*; they have the square form observed in that genus.

We are indebted to Professor Marsh for having described *Limnohyops laticeps*, although at the time of its description he created great confusion in the nomenclature by totally ignoring Leidy's previous description of *Palæosyops*. It was one of my first duties in taking up this investigation to unravel the work done by Marsh, and attempt to place it in its true relation to that done by Leidy. Marsh at the time of describing his genus *Telmatotherium* did not appreciate its true relationship to *Diplacodon* and later in his "Introduction and Succession of Vertebrate Life," places the genus *Palæosyops* next to that of *Diplacodon* in its evolution. This is an error. As I shall show in treating of *Telmatotherium*, this genus was probably the direct forerunner in the Bridger of the Uinta genus *Diplacodon* and I believe *Telmatotherium* to be the transition form between *Palæosyops* and *Diplacodon*. Also the statement made by Marsh that *Limnohyops*(=*Limnohyus*) is found lower in its geological horizon than *Palæosyops* is incorrect. They both occur in the Bridger proper, and there is no record of *Limnohyops* from the Wind River.

Professor Cope's collection of Palæosyops material is a small one; but owing to its unique character he has been enabled to describe a number of very interesting new species, which I find on comparison with other forms to be quite distinct. We are indebted to Cope for having described the earliest known species from the Wind River Eocene of Wyoming, namely, *P. borealis*; and from this formation he also described the genus *Lambdotherium* which he considers as the direct ancestor of the Palæosyops–Diplacodon line. We consider that *Lambdotherium* may have been the ancestor of *Palæosyops*, but certain characters of its dentition—for example, the loss of inf.-pm. 1—points to its being a side line, and not leading directly to *Palæosyops*. Professor Cope's collection contains only one skull referable to the genus *Limnohyops*, namely, his *L. fontinalis*, and in Telmatotherium material his collection is very limited. We shall not detain the reader with a long description of the original material upon which Leidy based his descriptions, but merely add that the type specimen of his *P. paludosus* is now in the Smithsonian Institution at Washington. His later material of *Palæosyops*, which was fully described in his report for 1873, is now in the Academy of Natural Sciences of Philadelphia. Professor Marsh's type of *Limnohyops laticeps* as well as his *L. robustus* and *Telmatotherium validus* are all in the Yale College Museum at New Haven. I was very fortunate in being able to examine Professor Marsh's type specimens, thanks to his courtesy. The material from which Professor Cope's types were described is all in his private collection: and lastly, the large collections made by the Princeton Exploring parties are deposited in the Museum of Geology and Archæology at Princeton College. These collections, I believe, contain all the known material referable to the *Palæosyopinæ*.

Geological Succession and Distribution of Species.—It is hardly necessary in this memoir to dwell upon the geology and subdivisions of the Bridger Eocene, as Prof. H. F. Osborn, in his memoir on *Loxolophodon*, gives a long description of the geology of the Bridger, and the faunal relations of the mammals found in this formation. He comes to the conclusion that there is abundant evidence to show that the Washakie is a later formation than the Bridger proper. He further shows that the nature of the rocks in the two subregions is different, and that the Washakie contains none of the higher genera of the Ungulates which are so characteristic of the Bridger, for example the genera *Loxolophodon, Amynodon, Triplopus, Achænodon*. Professor Scott[1], in his paper on the "Eocene Lacustrine Formations of the West," says that the Washakie is characterized by "a great reduction of the Creodonts, and Lemuroids, in the different type of the Dinocerata, in the presence of *Amynodon*, and in the fact that very few species are common to the two basins." Professor Scott,[2] in a later paper, further supports the above view and goes into a long discussion endeavoring to show that the Bridger and Washakie are separate formations having been deposited successively, the Bridger having as a whole an older fauna than the Washakie. My own studies upon the species of *Palæosyops* from these two formations, support the above views and indicate that the Bridger is characterized by many species of *Palæosyops* and allied genera which are not known to occur at all in the Washakie basin. I think it will be interesting to enumerate the different species that characterize the two subdivisions of the Bridger, as they furnish important evidence as to the distinctiveness of these two formations. We have already stated that *Palæosyops borealis* is the only species of this genus that is found in Wind River Eocene. Both the species of *Limnohyops* are confined to the Bridger. In the genus *Palæosyops* there are three species which are peculiar to the Bridger proper, namely, *P. lævidens*, *P. minor*, and *P. longirostris*. *Telmatotherium* has only one peculiar species confined to the Bridger, namely, *T. cultridens*. The Washakie has fewer peculiar species than the Bridger proper, but one of these belongs to the most specialized species of the genus, and leads almost directly to *Diplacodon*. These are *T. hyognathus*, the type with the much elongated jaw, and *P. vallidens* which is really a doubtful species and is intermediate between *P. paludosus*, and *Telmatotherium*. The species that are common to both formations are three in number, namely, *P. paludosus*, *P. megarhinus*, and *T. validus*. We see from the above enumeration that the less specialized member of the group, *Limnohyops*, is confined to the Bridger proper, whereas the most specialized genus of this subfamily occurs in both formations, it is true, but the most progressive species of the genus, *T. hyognathus*, has been only recorded from the Washakie. The above consideration will give support to the view that the Washakie has as a whole a more highly developed fauna as regards *Palæosyops* than the Bridger, and should be placed higher in its geological horizon than

[1]The Eocene Lacustrine Formations of the West. Proc. Am. Ass. Adv. Sci., 1887, page 277.

[2]The Mammalia of the Uinta Formation, p. 464.

the latter. The accompanying table will show the distribution of the species in this subfamily. As far as possible it has been arranged phylogenetically, and partially chronologically.

GEOLOGICAL DISTRIBUTION OF SPECIES.	EOCENE.						MIOCENE.			
			Bridger							
	Puerco	Wasatch	Wind River	Bridger	Washakie	Uinta	White River	John Day River	Deep River	Loup Fork
Titanotherium	– –	– –	–	–	–	– –	o.			
(Haplacodon)	– –	– –	–	–	–	– –	o.			
Diplacodon elatus	– –	– –	–	–	–	o.				
Telmatotherium hyognathus	– –	– –	–	–	o.					
Telmatotherium validus	– –	– –	–	o.	o.					
Telmatotherium cultridens	– –	– –	–	o.						
Limnohyops fontinalis	– –	– –	–	o.						
Limnohyops laticeps	– –	– –	–	o.						
Palæosyops longirostris	– –	– –	–	o.						
Palæosyops minor	– –	– –	–	o.						
Palæosyops vallidens	– –	– –	–	–	o.					
Palæosyops megarhinus	– –	– –	–	o.	o.					
Palæosyops lævidens	– –	– –	–	o.						
Palæosyops paludosus	– –	– –	–	o.	o.					
Palæosyops borealis	– –	– –	o.							
Lambdotherium popoagicum	– –	– –	o.							
Lambdotherium ?	– –	o.								

CLASSIFICATION.

The discovery by M. Filhol of the relations of *Chalicotherium* to *Macrotherium* has made an entire rearrangement of this family necessary, so that a new family name must be applied to the group including the genus *Palæosyops* and allied genera. Professor Cope[1] has taken this opportunity to propose that *Chalicotherium* be placed in a new order entitled the *Ancylopoda*, and has likewise instituted a new family name for *Palæosyops* and allied genera—namely, the *Lambdotheriidæ*; this is derived from his genus *Lambdotherium*,[2] which was described a long time after *Palæosyops*[3] had been by Leidy. I accordingly cannot accept Cope's proposed name for this family, as the family name of a group must, according to the rules of nomenclature, be derived from the oldest generic name, that is to say from *Palæosyops*, which would give us the name *Palæosyopidæ* for this family. I find in looking over Professor Cope's various papers from 1879–87, upon the arrangement of the fami-

[1] Am. Nat., March 1889, p. 152.

[2] Am. Nat., 1880, 746.

[3] Hayden's, Prelim. Rpt. of Geol. Surv. of Montana, 1872, p. 358.

lies of the Perissodactyla, that in his first paper upon this subject[1] he did not subdivide the family *Menodontidæ* from the *Chalicotheriidæ*. He included the genera *Palæosyops* and *Menodus* all under the family *Chalicotheriidæ*, and he follows this arrangement in his second paper upon the classification of the Perissodactyla.[2] In his third paper upon this subject Professor Cope, for the first time, separated the *Menodontidæ* from the *Chalicotheriidæ*, basing the differential characters of the two families upon the simplicity or complexity of the premolar series respectively. Both Schlosser and Osborn[3] have noticed the close affinity between *Palæosyops*, *Diplacodon* and *Titanotherium*, and consider that on account of the transition characters of the premolars of *Diplacodon*, the three genera in question should be united into one family. Lydekker,[4] in his Manual of Palæontology, follows Cope in the arrangement of this family, including in it the genera *Palæosyops* and *Titanotherium*, and placing *Chalicotherium* in a distant family of the Perissodactyla. I should also add that Lydekker places *Palæosyops* in the family *Lambdotheriidæ* proposed by Cope. Steinmann and Dœderlein[5] form three subfamilies for the genera *Palæosyops*, *Titanotherium* (=*Brontotherium*), and *Chalicotherium* respectively, combining these all in the family *Chalicotheriidæ*. After considering the question of the union of these genera into one family, I quite agree with Osborn and Schlosser, and see no real line of family distinction between them. I think that *Palæosyops* and allied genera, *Diplacodon* and lastly *Titanotherium*, should be placed in the family *Titanotheriidæ*, proposed by Osborn.[6]

It appears to me that the arrangement proposed by Dœderlein, of placing the genera of this family into subfamilies, is a very good one, and I shall accordingly follow it.

General Characters of the family Titanotheriidæ.—The family *Titanotheriidæ* may be defined as follows: Skull elongated, with zygomatic fossa prolonged beyond posterior limit of molars. Orbit small and not separated from temporal fossa behind. Nasals elongated and reaching at least as far as premaxillary symphysis. Lateral nasal notch deep. Nasals with or without horns. Auditory processes well developed. Postglenoid process large. Occiput broad with prominent descending paroccipital processes. Alisphenoid canal much elongated. Foramen ovale distinct and widely separated from the for. lacerum medium. Tympanic bone not coossified with petrous. Superior molars of the buno-selenodont type, with symmetrically developed external V's, separated by a prominent median buttress. Internal cones of molars separated from external lobes. Intermediate tubercles generally well developed. Lower molars of the lopho-selenodont type, consisting of double V's, with the posterior crest

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[1] Bull. U. S. Geol. Surv., 1879, p. 228.

[2] Am. Nat. April, 1881, p. 340.

[3] Uinta Mammalia, p. 141, Aug. 20, 1889, (Trans. Am. Phil. Soc. Vol. 16).

[4] Manual of Palæontology, Nicholson and Lydekker, 1889.

[5] Elemente der Palæontologie, 2 Band, p. 776.

[6] Loc cit.

of the anterior V, and the anterior crest of the posterior V in continuity internally. Posterior tubercle of last inferior molar always present. Manus of the paraxonic type, with four functional digits. Carpus broader than high. Lunar with nearly subequal magnum and unciform facets, and consequently scaphoid widely separated from unciform. Magnum small. Pes with three wide spreading digits. Astragalo-calcaneal facets generally widely separated. A large astragalo-cuboid contact. Fibulo-calcaneal facet present. Navicular broad and low. Metatarsals of the alternating type.

As already proposed, the family *Titanotheriidæ* may be divided into two subfamilies with the following definitions.

A.	None of the premolars molariform.	PALÆOSYOPINÆ.
B.	Some of the premolars molariform.	TITANOTHERIINÆ.

General Characters of the Palæosyopinæ.—Dentition.—i.$\frac{3}{3}$ c.$\frac{1}{1}$, pm.$\frac{4}{4}$, m.$\frac{3}{3}$. The subfamily *Palæosyopinæ* is distinguished above all from that of the *Titanotheriinæ* by the simplicity of the premolars, and in none of the genera are any of these teeth as complex in their structure as the true molars. Only in the highest genus of this subfamily, namely *Telmatotherium*, do we find any signs of the premolars taking on the characters of the molars. Then again in this subfamily, all its members as far as known have a full complement of both upper and lower incisors, and also the canines are very much developed, much more so compared with the size of the animal than in the other subfamily. The first superior premolar is a double fanged tooth, with or without heels; the second tooth of the series above may have its internal cone rudimentary. The last two upper premolars are always triconate in structure. As a rule the last superior premolar is much smaller than the first superior molar. This rule applies especially to the more primitive members of this subfamily. The variation in the details of the molars in the different genera is considerable; and when we compare the undifferentiated molars of *Lambdotherium* with those of *Telmatotherium*, we can appreciate the great specialization of the one genus over the other. This applies especially to the development of the external V's, and the crowns of the teeth. In *Lambdotherium* the V's are shallow and the external cusps of the same show strongly their original bunodont character. The crowns of the molars in this genus are very low. On the other hand, in *Palæosyops* these characters become more specialized and progressive; whereas in *Telmatotherium* the characters of its molars approach more nearly those of *Titanotherium*, and are intermediate in character between the latter genus and *Palæosyops*. In the lower genera the external cingulum of the true molars is wanting. In *Telmatotherium* the external cingulum is a very conspicuous character of the molars. The intermediate tubercles are variable in this subfamily, and we can safely say that as a whole the less specialized genera, such as *Lambdotherium* and *Palæosyops*, have the greatest development of the intermediates. This is specially noticeable in *Lambdotherium* where the development of the protoconules has gone so far as to form a true transverse crest; there are also signs of a posterior crest in this genus. The development of transverse crests is the great exception in this subfamily; but there are signs of these in *L. laticeps* and in *P. borealis*. The first and second superior molars are always provided with two well developed internal cones in all the genera of this family; but the variations in the number of internal cones of the last upper molar are considerable. In *Limnohyops* this molar has two internal cones, whereas in *Palæosyops* and *Telmatotherium* the hypocone of the last upper molar becomes rudimentary, although all stages of the degeneration of the hypocone may be observed within the genera already mentioned. The variation in the form of the last inferior molar with its tubercles will be considered later. Diastemas may be present in the dental series of some species, and the intervals increase as we approach the higher forms, although a reversion to the primitive form takes place in *Titanotherium*, which genus is without a diastema in its dentition.

Skull.—The general form of the skull in the two subdivisions of this family is very different. All the members of the *Palæosyopinæ* have small skulls compared with those of the *Titanotheriinæ*; and, moreover, in the former the facial region is much longer in comparison with the cranial portion than in the latter subfamily. The marking off of the orbit by postorbital processes from the temporal fossa is a well marked character of *Palæosyops*. The coalescence of the temporal ridges to form a sagittal crest is characteristic of the *Palæosyopinæ*, whereas in *Titanotherium* no such crest is found, the roof of the cranium being very broad, flat and limited laterally by the strongly developed temporal ridges. The nasal bones in *Palæosyops* are more slender and elongated as compared to those of *Titanotherium*; they do not project beyond the premaxillary symphysis, and the lateral nasal notches are smaller than in the last named genus. The nasals never bear any horns, nor does any other part of the skull in the *Palæosyopinæ*. The auditory processes are large, and the postglenoid and posttympanic remain separated. In the lower jaw the anterior extension of the symphysis beyond the premolars is much greater than in the *Titanotheriinæ*. In the latter group the anterior portion of the symphysis is very much abbreviated and there is, consequently, a crowding together of the teeth in this region. The brain is less convoluted, and the forebrain is more widely separated from the hind brain than in the *Titanotheriinæ*.

Carpus.—In the carpus the lunar diameters are more nearly equal than in *Titanotherium*, where the transverse diameter of the former is much greater than the vertical. The distal facets of the lunar are more unequally divided, the lunar-magnum facet being nearly vertically placed in some genera. As a consequence of this the distal portion of the lunar forms a beak-like process, which in one genus (*Limnohyops*) may nearly divide the second row of carpals as far as their distal face. The scaphoid and unciform are more displaced in the *Palæosyopinæ* than in the *Titanotheriinæ*. The articulation of metacarpal III, and the unciform is very large. The transverse extent of the magnum is less, comparatively, than in the *Titanotheriinæ*. As a whole the carpus in *Palæosyops* is more elongate, its transverse axis being less in proportion to its vertical. This also applies to the elements of the tarsus.

Tarsus.—The tarsus of *Palæosyops* is proportionally higher and narrower than that of *Titanotherium*, also the metapodial region is much less spreading. The astragalo-calcaneal facets are not as widely separated as in the *Titanotheriinæ*; and, in fact, in some of the smaller species of the *Palæosyopinæ* the sustentacular and inferior may be continuous. In *Palæosyops* the sustentaculum is very largely developed, whereas in *Titanotherium* this facet is small. The astragalo-cuboid facet is much smaller than that of *Titanotherium*, and consequently the navicular is less reduced than in the latter genus. A small contact takes place between the cuboid and metatarsal III. The cuboid is rather narrow and high. A small fibulo-calcaneal facet is developed in *Palæosyops*, but there is no tibio-calcaneal contact. The gap between the astragalus and calcaneum is very small in the *Palæosyopinæ*, and the astragalar trochlea are deeper than in the *Titanotheriinæ*.

SYNOPSIS OF THE GENERA OF THE PALÆOSYOPINÆ.

I. All three incisors present in each jaw.	
A. External lobes of sup. molars very oblique and shallow.	1. LAMBDOTHERIUM.
B. External lobes of sup. molars straight and deep.	
a. premaxillary symphysis short and round, last sup. molar with two internal cones .	2. LIMNOHYOPS.
last sup. molar with one internal cone .	3. PALÆOSYOPS.
b. premaxillary symphysis elongate and narrow	4. TELMATOTHERIUM.
(II. Only two incisors present in each jaw . .	5. HAPLACODON.(³)

The above analytical table of the genera of the *Palæosyopinæ* differs radically from the last table of the *Chalicotheriidæ* proposed by Professor Cope[1]; of course this difference is due to the discovery of the position of *Chalicotherium*.

[1] Am. Nat., 1887, p. 1061. [2] Am. Nat., June 1882, p. 522.

In Professor Cope's table of the *Chalicotheriidæ* he includes the following genera, namely—*Ectocium*, *Epihippus*, and *Pachynolophus*, which I exclude from the above table. At the time of the description of *Ectocium*,[2] (see reference above.) Professor Cope seemed uncertain where to place this genus, and says "if it is not *Condylarthrus* it must be placed in the *Chalicotheriidæ*." We think that the dental characters of *Ectocium* are certainly much nearer to the *Condylarthra* (*Protogonia*), than to *Palæosyops*, and for that reason we have excluded it from our table. The feet are also totally unknown. In *Epihippus* the molars are very closely related to those of *Mesohippus* and surely belong in the Equine line, and the fact that the third and fourth inferior premolars are as complex as the true molars would exclude it from the *Palæosyopinæ*. In the last genus to be considered, namely *Pachynolophus*, its affinities seem to be rather more Equine than Telmatotherioid.

[3] Included by Cope in *Titanotherium* (=*Menodus*). Contr. to Canadian Pal., vol. III, 1891, p. 13. Some of the dental characters of this form are purely transitional.

PALÆOSYOPS.

Syn. (*Limnohyus*—Marsh.)

The dentition of *Palæosyops* has been partially described by Leidy, although his descriptions are faulty in not indicating distinctly the specific difference between the species. He was either not familiar with the genus *Telmatotherium*, or considered it the same as *Palæosyops*, for in the material described by him there are no teeth which can be referred to *Telmatotherium*. Leidy, in giving the dental character of his two species of *Palæosyops*, seems often uncertain under which species he should place new material, and is constantly doubting their specific distinction. He has given us a tolerably full account of the dentition of *P. minor*, but he compares the dentition of *P. paludosus* with that of the former species, and speaks of their very close similarity in dentition; but he does not point out fully the specific characters of each species. The following generic characters are mainly derived from the typical species—viz: *P. paludosus*.

Generic Characters:—Dentition:—The incisors in this genus form a closed series, their crowns being short and triangular in outline. The posterior face of the incisors is not deeply excavated as in *Telmatotherium*, and there is no prominent basal ridge as in the latter genus. The diastemas between the canines and incisors may be large, but the posterior canine diastema is generally very small.

The canines are very large, bear-like tusks, and round in section. The crowns of the upper premolars are lower than those of *Telmatotherium*, and their external lobes are less acute. The first premolar is much simpler than that of *Telmatotherium*. The second has a well developed internal lobe. In the last tooth of this series the external lobes are generally separated by a median buttress, which is wanting in *Telmatotherium*. In the less specialized member of the genus the transverse diameter of pm. 4 and m. 1 is considerable. The intermediate conules of the premolars are generally wanting. In the inferior premolar series the first tooth is quite simple in structure, having no prominent heels. The second has no rudimentary internal cone as in some species of *Lambdotherium*, and its anterior cone is larger than the posterior. The fourth inferior premolar differs from that of *Telmatotherium* in being simpler in structure. The superior true molars have low crowns and their transverse axes exceed the antero-posterior. The external V's in this genus are round and narrow; their anterior buttress is very prominent and the median buttress is not strongly constricted off. Prominent ribs may be present in some of the species of this genus on the external face of the superior molars. In contrast to *Limnohyops* only the protoconules are developed on the true molars, the presence of a metaconule being a very rare occurrence in this genus. The internal cones of the molars are round, blunt, and the hypocone of m. 1 and m. 2 is more strongly developed than in *Telmatotherium*. The last superior molar has only one internal cone, but traces of a hypocone may be present on this tooth. As a rule nearly all the species in this genus have the external cingulum wanting. The inferior molars have much lower and less specialized crowns than in *Telmatotherium.* This applies especially to the V's, where crests are less developed than in the former genus. The last inferior molar is short, broad and its tubercle may be highly specialized.

The skull may undergo various modifications as to form in this genus. It is generally much elongated, with the facial portion short and the zygomatic fossa elongated, thus bringing the orbit well forward over the molars. The premaxillaries are highly characteristic, being short, compressed and with a small round median symphysis. The nasals are shorter and broader than in *Limnohyops*, but not so strongly arched laterally as in *Telmatotherium.* The occipital crests are well developed and the zygomatic arches may undergo considerable variation as to development. The auditory processes are distinct, the post-glenoid being generally elongated. The jaw symphysis is short and not horizontally placed. The inferior border of the jaw is strongly incurved.

The brain is of a low type, with the subdivisions well separated. The cerebrum is small, but convoluted. The mid-brain was probably partially exposed. The cerebellum is very broad transversely, being as broad as the hemispheres. The olfactory lobes were very large and extended considerably in front of the cerebrum. The characters of the axial skeleton resemble closely those of the Tapir, although the zygapophyses of the posterior dorsal region are involute in form. The manus is short and broad. The distal facets of the lunar are subequal. The magnum is broad and not high. The metapodials are short and broad. In the tarsus the astragalo-calcaneum facets are generally widely separated, but considerable variation may be present in this respect. There is a large astragalar cuboid contact. The contact between the cuboid and metatarsal III is, as a rule, wanting.

The pelvis was short and broad. The iliæ were not subdivided, being Rhinocerotic in form.

SYNOPSIS OF THE SPECIES OF THE GENUS PALÆOSYOPS.

A. Ascending ramus of mandible short.
   1. Nasals not expanded distally.
   a. Size large.
      Inferior molars stout and broad, posterior tubercle a cone. *P. paludosus.*
      Inferior molars high and long, posterior tubercle a cone. *P. vallidens.*
   b. Size medium.
      Superior premolar 2 with one external lobe . . *P. laevidens.*
      Superior premolar 2 with two external lobes . . *P. minor.*
   c. Size small.
      Superior premolar 4 with a protoconule . . . *P. borealis.*
   2. Nasals expanded distally.
   a. Size medium . . . . *P. megarhinus.*

B. Ascending ramus of mandible very long.
  a. Size medium.
    Inf. molars stout and broad, posterior tubercle a lobe. *P. longirostris.*

PALÆOSYOPS PALUDOSUS.

(*P. major* Leidy) (*Limnohyus robustus* Marsh.)

The description of some scattered molars of this species by Leidy[1] in 1870 is the first indication we have of the existence of this subfamily. Later, in his "Extinct Vertebrata of the West," he added largely to his above preliminary notices, and compared the teeth of this species to his *P. minor*, but did not give a full description of the dentition. Leidy's later material which he referred to this species, largely consisted of lower molars,[2] the material for the superior dentition being represented by scattered molars only. Scott and Osborn[3] in their report described the canines and incisors, and referred to Leidy for further particulars as to the dentition in this species. Cope also follows the above authors and refers to Leidy's description. As this, in some respects, is the most important species of this subfamily, and a large collection of the teeth being in the Princeton Museum, I shall give the descriptions of its dentition in detail and point out especially its specific character; I shall also dwell largely upon the variable characters of the dentition exhibited by this species.

General Description of Dentition.—There are two very fine specimens of portions of skulls of this species in the collection; one containing both the upper and lower series of molars (No. 10,009). The other specimen is a part of the facial region of one side complete (No. 10,282 b), which has the incisors and molars in a very good state of preservation. These two skulls are very interesting, as after a close study of their characters I can find no specific difference between them; but they exhibit certain variations in their dentition, especially in relation to the size of the teeth and the unwrinkled condition of the enamel. These differences I consider as a sexual variation, and in describing the dentition of this species, I shall refer to the variation shown by the male and female respectively. An attempt to describe the dentition in both sexes of a fossil animal is, I think, quite a novelty, as the investigator in this branch of science sees very little mentioned about sexual differences.[4] I imagine in a great many cases we may have different species described under the same genus, whereas really they may be only sexual differences of the same species.

The superior incisors in this species are arranged in a semi-circle, the increase in size being from within outwards. The external incisor is separated from the canine by a diastema. The incisors in this species differ from those of *Telmato-*

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[1] Proc. Acad. of Nat. Scien. Phil., 1870, page 113.

[2] Extinct Vertebrate Fauna, etc., plate 24, figs. 1 and 2.

[3] E. M. Museum Bulletin of Princeton College, 1877, page 28.

[4] Marsh's Monograph of the Dinocerata.

therium in that both their anterior and posterior surfaces are convex, and there is no prominent basal ridge so characteristic of the incisors of *Telmatotherium*.

The incisors of the male (No. 10,282 b) are larger and more massive than those of the female (No. 10,009). In the male the external incisor is a very powerful tooth, with a very thick and wide spreading crown. The diastema separating this tooth from the canine is larger in the male than in the female. The canine of the male is a huge bear-like tusk. It is round in section, its posterior face exhibiting a slight longitudinal ridge. The diameter of the canine in the male is much greater than in the female, and its section is rounder. The post canine diastema in both sexes is about equal. The total measurements of the superior molar series of *P. paludosus* show a great range of variation, and the accompanying table will illustrate this point. We may consider the extreme forms of this species as varieties.

Table of measurements showing the variation in the dentition of Palæosyops paludosus.

	No. 10,276.	Leidy's fig. of skull.	No. 10,009.	No. 10,282 b.	No. 10,118.
Entire molar series	·158	·162	·172	·178	– –
Length of premolars	·065	– –	·070	·074	– –
Length of true molars	·095	·100	·102	·105	– –
Sup. molar 3 trans.	·041	·043	·044	·046	– –
Sup. molar 3 ant.-post.	·038	·040	·039	·042	– –
Sup. molar 1 trans.	·031	– –	·031	·035	– –
Sup. molar 1 ant.-post.	·030	– –	·032	·032	– –
Sup. premolar 4 trans.	·026	– –	·025	·027	– –
Sup. premolar 1 trans.	– –	– –	·008	015	– –
Entire molar series (inf.)	– –	·190	·187	– –	– –
Premolar series (")	– –	– –	·082	– –	– –
True molar series (")	– –	·112	·107	– –	·105
Inf. molar 3 trans.	– –	·025	·024	– –	·020
Inf. molar 3 ant.-post.	– –	·051	·047	– –	·048
Diameter sup. canine	– –	– –	·020	·025	– –
Sup. pre-canine diast.	– –	– –	·010	·013	– –
Sup. post " "	– –	– –	·011	·010	– –
Post. tubercle inf. molar 3 trans.	– –	– –	·012	– –	.015
Post. tubercle inf. molar 3 ant.-post.	– –	– –	·013	– –	·013

We see from the table that the range of variation in the size of the molar series is greater than in the premolars, although the individual form of the premolars also shows considerable difference. The first superior premolar in the female is very small; its crown is a simple cone with a slightly elongated posterior heel. In the male this tooth is very much larger; although conical in form its transverse diameter is very great compared to the other individual of this species; its outer face is convex, the inner one being slightly concave. The premolar 1 is placed close to the second, there being no interval between the teeth in the superior series. The second premolar is a trilobate tooth, its external lobes being equal, as is generally the case in all the superior premolars of this species.

The third premolar differs from the foregoing in being larger; its crown is higher, and an anterior buttress appears for the first time. The external lobes in this tooth show no signs of separation. The fourth premolar is an enlarged representative of the preceding tooth with the addition of an enlarged anterior buttress, and the separation of the external lobes by a well marked median fold. The anterior border of this tooth is nearly straight. In the preceding premolar it is very oblique. In all the premolars of this species the internal lobes are conical, show little signs of becoming concave externally, and have sharp lateral crests, as is seen in *Telmatotherium.* The intermediate conules are absent on the premolars of this species. In the male the premolars have the same general characters as already given for the female, but the transverse diameter of the third premolar is much less than that of premolar 4. Its form is much more nearly square than that of No. 10,009. The last premolar in this individual is a larger tooth than in the female; although, as is always the case with this species, the transverse diameter of the last premolar is less than that of the first true molar. This tooth in the male has its form more nearly rectangular than that of the female. In Professor Cope's collection there is a series of superior molars of this species in which the premolars have much higher crowns than in the Princeton examples; the external lobes are sharper and in the last premolar they are not separated by a median buttress. All these characters point to the genus *Telmatotherium*, and we may consider this specimen as intermediate in character between the typical examples of *P. paludosus* and *Telmatotherium.*

Another character of Cope's specimen is that the superior premolars 2 and 3 have complete basal internal cingula. In all the premolars of this species that I have examined the basal cingula are incomplete. This only proves what a variable character a complete or incomplete cingulum is, and that it cannot be used for specific definition. We may add that in a species of *Hyrachyus* which I have examined, the same premolar of opposite sides had on one side a complete cingulum and on the other side the cingulum was incomplete.

The superior molars (Plate XII, fig. 17) in this species are large, with very low crowns and their transverse diameter exceeds their antero-posterior. They differ in this respect from those of *Telmatotherium* in which the form of the molar is nearly square. In the latter genus the crowns of the teeth are very high. In this species the external V's are very strongly developed, although they are much narrower and more concave than in *Telmatotherium.* In some molars a median fold is present on the anterior V, although this is a variable and a primitive character. The buttresses of the external faces of the molars are very large; the anterior is widely prolonged beyond the posterior limit of the one in front; the median buttress is low and prominent, but not constricted off so much from the tooth as in *Telmatotherium* and the smaller species of *Palæosyops*. The chacraters of the external lobes and buttresses in this species offer a sure means of distinguishing it from those of the species of *Telmatotherium*.

The presence of the intermediate conules is very characteristic of this species, and upon each upper true molar a protoconule is always present. This lobule in *Palæosyops paludosus* is very large and prominent, especially on superior molars 1 and 2. In the last upper molar the protoconule is much smaller, it being largest on molar 1 and decreasing posteriorly in size. There is no metaconule on molars 1 and 2, although this conule may be present on molar 3. In the collection of the Princeton Museum there is a very interesting last upper molar, (Plate 12, fig. 18), which has both the intermediate conules strongly developed, especially the protoconule, which is connected with the anterior cingulum by a prominent prolongation. In this molar the external V's are rather irregular in form, the anterior one having a prominent median fold. These characters are more primitive than those found in a typical molar of this species and point to *Lambdotherium*, where the external lobes of the molars are not as highly differentiated as in *Palæosyops*. The external face of the true molars is totally devoid of a cingulum, a character which readily distinguishes this species from *P. minor*.

The presence of an external cingulum is a prominent character in the dentition of *P. minor*. The anterior cingulum is very strongly developed in this species; it forms a very prominent transverse ridge, distinct from the protoconule of the molar, being continuous anteriorly and externally with the large anterior buttress so characteristic of this species. The internal cingulum of the true molars is only very slightly developed. The internal cones of the molars are large and rather sharp; there are no signs of connecting ridges between them and the external lobes of the molars.

The hypocones of molars 1 and 2 are rather large and not placed so far behind and to the inside as in *Telmatotherium*. The presence of a small rudimentary conule (hypocone?) upon the last upper molar of this species is not uncommon. We have such an example in the Princeton collection on No. 10,276. The fine series of upper molars of this species in Professor Cope's collection also show a small hypocone upon the last molar. The discussion of this character and its relation to the two-coned form of molar occurring in *Limnohyops* will be considered under the head of that genus. I may merely add here that Marsh's *L. laticeps* is very closely related in its dental characters to *P. paludosus*. The two series of molars that have been described under this species as belonging to the male and female respectively offer no other peculiar characters in the conformation of their lobes, but in the condition of the enamel they present a striking difference, in the fact that in the supposed male the enamel is strongly wrinkled, whereas in specimen No. 10,009 (supposed female) the surface of the enamel is perfectly smooth. This character is an important one as Cope[1], in his specific table of this family,

[1] Tertiary Vertebrata, page 699.

considers the condition of the enamel as a specific character. From the abundance of material of *P. paludosus* in the Princeton collection, I can positively state that wrinkled or unwrinkled enamel will not hold as one of the specific characters of this species, as we have teeth showing all grades of wrinkling in the same species. The larger molars with strongly rugose enamel, I believe very probably belong to the male, whereas the smaller and smoother enameled molars probably pertain to the females.

I should add also that the wrinkled condition of the molars in this species is not dependant upon age, as the two series of molars show about the same stage of abrasion.

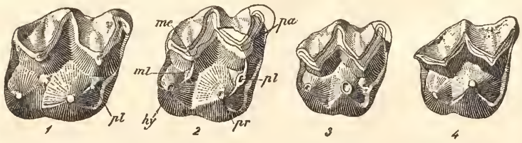


FIGURE 1. Second superior molar; *1. Palæosyops paludosus. 2. Limnohyops laticeps. 3. Palæosyops minor. 4. Telmatotherium cultridens.* Two-thirds natural size.
pa.=paracone, me.=metacone. pr.=protocone, hy.=hypocone, pl.=protoconule, ml.=metaconule.

Inferior Dentition.—The lower incisors are triangular in form, and are without the internal basal ridge which is so characteristic of these teeth in *Telmatotherium.* Their position in the jaw is also much less procumbent than in the latter genus. There was probably no precanine diastema in the lower jaw of this species. The lower canine is very large, and less divergent than in *Telmatotherium.* The canine is internally flattened, the external surface being convex with prominent anterior and posterior cutting edges. The first premolar is placed close to the canine; it is a single fanged tooth with a conical crown, the posterior portion of the same showing a slightly enlarged heel. A considerable diastema intervenes between premolar's 1 and 2 in this specimen (No. 10,009), although this appears to be a variable character, as in the Cope collection there is a mandible of this species in which there is no well marked diastema in the lower jaw. In premolars 2 and 3 the protoconid is much larger than the hypoconid, although the protoconid of the second premolar seldom reaches the large size that it does in *Telmatotherium,* where the two cones of this tooth show a much greater difference in size. In the last premolar the metaconid is well developed, and also the anterior crest of the V is well shown and joins internally a small paraconid. In *P. paludosus* the last premolar is a less highly developed tooth than in *Telmatotherium,* as in the latter genus both V's of the last premolar are well expressed, the posterior crest of the posterior V being well differentiated in *T. cultridens,* whereas in *P. paludosus* this is not the case; in other words, the last inferior premolar in *Telmatotherium* has almost assumed the form of a true molar, but the entoconid is still wanting to form the double symmetrical V's of the true molars. Both the internal and external face of the premolars are without cingula. The crowns of the inferior molars of *P. paludosus* are low and very broad, they differ in this respect from those of *Telmatotherium*, where the form of the molar is very high and elongated. The valleys between the lobes in this species are shallow and the molar cusps do not project so much above them as in those of *Telmatotherium*. The crests of the V's are weakly developed and do not present such sharp cutting edges as seen in the last mentioned genus. We have in the last inferior molar a very characteristic tooth in this species, and one which readily distinguishes it from *P. minor* and the different species of *Telmatotherium*. In the typical form this molar is unusually broad and heavy; its crown is very low compared with that of *Telmatotherium*. The posterior tubercle of the last inferior molar is simply a small cone placed in the middle axis of the tooth, and is connected with the entoconid of the molar by a feebly marked crest. A lower jaw of another individual of this species, No. 10,118, shows considerable variation in the characters of the last molar. In this specimen the crown of the tooth is much narrower, and the diameter of its posterior tubercle is nearly as great as that of a whole tooth. In this variety the posterior tubercle is still a cone. I have examined at least six jaws of this species, and they all correspond in the broad form of the molars and small size of the tubercle of the last molar.

TEETH MEASUREMENTS OF PALÆOSYOPS AND LIMNOHYOPS.

Upper Jaw.	P. paludosus.	L. laticeps.	P. lævidens.	P. megarhinus	P. minor.
Entire molar series	·172	·155	·140	·148	·153
Length of true molars	·102	·095	·085	·085	·085
Length of premolars	·070	·064	·056	·066	·066
Premolar 4 { trans.	·024	·026	·022	– –	·021
Premolar 4 { ant. post.	·021	·020	·019	– –	·018
Molar 1 { trans.	·030	·031	·029	– –	·023
Molar 1 { ant. post.	·031	·030	·026	– –	·025
Molar 3 { trans.	·044	·045	·036	·039	·035
Molar 3 { ant. post.	·039	·041	·039	·037	·036
Lower Jaw.					
Entire molar series	·187	– –	– –	– –	·157
Length of premolars	·082	– –	– –	– –	·063
Length of true molars	·107	– –	– –	– –	·100
Molar 3 { trans.	·024	– –	– –	– –	·020
Molar 3 { ant. post.	·047	– –	– –	– –	·040
Molar 3 tubercle { trans.	·012	– –	– –	– –	·010
Molar 3 tubercle { ant. post.	·013	– –	– –	– –	·010
Jaw.					
Total length of jaw	·364	– –	– –	– –	·300
Depth below last molar	·075	– –	– –	– –	·068
Length of symphysis	·085	– –	– –	– –	.060
Breadth of symphysis below 1st premolar	·067	– –	– –	– –	– –

The variety last described, No. 10,118, we may consider as an extreme form of this species, and we shall hereafter see when treating of *P. vallidens*, that in the latter species we have intermediate dental characters pointing to the species under consideration.

The Skull.—(Pl. 10, fig. 1.) The skull figured is a composition of the two very fine specimens in the museum of the Academy of Natural Sciences of Philadelphia, figured by Leidy in his work; they are an occipital region and a facial portion of a skull from another individual. The restoration of the lower jaw is derived from the fine mandible in the Princeton collection No. 10,009. Leidy[1] has already given us a restoration of the skull of this species in his report, but in some respects it is rather exaggerated; for example, the occipital region, in comparison with the facial, is too high; the anterior portion of the temporal fossa is too much excavated, and the curvature and form of the zygomatic arch is incorrect. The general dimensions of the skull of this species as compared with that of the Tapir are very much broader and heavier, although their anterior and posterior dimensions are about equal. The facial axis of the skull was probably slightly bent upon the cranial. In the Tapir on the other hand, these axes are in the same straight line. The form of the facial region is very different from that of any living Perissodactyle, as on account of the long and overhanging nasals it gives this portion of the skull a different aspect from that of the Tapir, where the nasal bones are much abbreviated and reduced.

The facial region of the skull is rather compressed, with a convex superior surface which gradually rises to the interorbital region. The latter portion is very much expanded and is depressed between the orbits, which form an abrupt concavity, from which posteriorly the frontals rise suddenly to form the much enlarged forehead so characteristic of this species. The general form of the cranium in *P. paludosus* in many respects resembles that of the Tapir; that is to say, the frontal region is higher than the occipital, and forms a high and flat forehead transversely, being strongly convex from before backwards. The post orbital processes of the frontal are largely developed in this species, and the anterior temple ridges rising from them are very prominent. The surface of the skull between the temple ridges is very broad and slightly convex. From the interorbital region the temple ridges converge, but do not meet to form a sagittal crest until near the junction of the latter with the occipital border. The lambdoidal crest is well-developed in this species, and extends laterally as far as the exoccipital region, but it is not nearly so much developed as in *Limnohyops* where it is very heavy. The occiput of *P. paludosus* is much broader than high, the portion above the foramen magnum being directed forwards. The superior portion of the occiput is concave and overhung by the lambdoidal crest. Viewed from the side, the skull shows nearly the same position of the

[1]See Report U. S. Geol. Surv. of Terri. for 1873–Pl. xxxi.

orbit as the Tapir's skull. The orbit is situated slightly in advance of the middle of the skull, its anterior termination being above the middle of the second molar. In the Tapir the orbit has a slightly more anterior position, its anterior limit being above the first true molar.

The orbit in this species is small and bear-like; it looks more forward and outward than in the Tapir's skull, and is separated from the temporal fossa by a strongly marked postorbital process. The antero-posterior extent of the temporal fossa is very great, and its height at the middle is very much greater than in that of the Tapir; the external surface is deeply concave, its middle portion at the frontal squamosal suture being slightly convex. Comparing this region with that of the Tapir's skull we see how much more reduced the cerebral volume must have been than in the Tapir. Superiorly and anteriorly the temporal ridges overhang the temporal fossa very prominently. Comparing the size and form of the temporal fossa in this species with that of the living Carnivores, we find that the lateral convexity of the walls and the reduction of the crest in the latter are much less than in *Palæosyops paludosus*, and it is not until we go back to the Eocene Creodonts, that we see a like reduction of the brain, and a concomitant deepening of the lateral cranial region of the skull. In the form and weight of its zygomatic arch this species differs widely from recent Perissodactyles, and approaches the Carnivores, although we have yet to see one of the Felidæ in which the zygomas are as strongly developed as in *P. paludosus*. The zygomatic arch in this species is very strongly compressed, its posterior portion is widely set off from the temporal region of the skull, and in this character approaches that seen in the Bears. The middle portion of the arch first descends, and then gradually ascends to the strongly compressed and plate like malar portion.

The palate in this species is flat and broad, and its roof is not so convex as in that of *Telmatotherium*. The posterior extension of the palate is to the posterior border of the second molar. The basioccipital region of the skull is very broad; and this is especially marked between the postglenoids, where this region is nearly twice as broad as in the Tapir's skull. Like that of recent Perissodactyles the lateral portion of this region is provided with large vacuities which lead into the cranial cavity.

Premaxillaries.—The premaxillaries in this species are short, rounded and strongly depressed. Viewed from the front these bones are convex and show no median keel, the presence of which is so characteristic of *P. megarhinus*. The outline of the premaxillaries from below is round; posteriorly they send off two horizontal maxillary processes including between them, and upon each side, the separated incisive foramina. This region of the skull in *Palæosyops paludosus* strongly resembles that of the Carnivores in form; it is broad and short as in the latter order. In the skull of the Bear the premaxillaries are prolonged farther upon the palate than in the skull of *P. paludosus*; in the latter they are very short and do not extend farther upon the palate than a line drawn between the anterior border of the canines. The premaxillary symphysis is round and short in this species; its form is in strong contrast to that found in the allied genus *Telmatotherium*, where the symphysis is much elongated and narrow. The premaxillo-maxillary suture is situated about midway between the outer incisor and the canine; its superior termination is on a line with the posterior border of the latter. The nasal notches in this species are moderately deep and their upper and lower margins are less sinuous than in *P. megarhinus*. Above, the broad plate-like nasals form the roof of the nasal cavity, being prolonged anteriorly as far as the premaxillary suture. The premaxillaries form the lower half of the nasal notch, the latter terminating above the anterior border of the third premolar. The portion of the skull between the superior termination of the nasal notches and the orbit is elongated and broad. In the Tapir, owing to the great reduction of the nasals and consequent posterior prolongation of the anterior nares, the lamina between the orbit and nasal cavity becomes very narrow and is bordered internally by a long ascending process of the maxillary, which, in the skull of *Palæosyops paludosus*, is very short.

Nasals.—The nasals are very broad in comparison with their length in this species. They were not coosified, and not nearly so strongly arched laterally as in *Telmatotherium*. Their superior surface is convex and their external border in front is curved in outline, terminating at the free extremities in rather pointed and rounded borders. The posterior portion of the nasals is very broad and flat. The posterior terminations of the same were probably on a line with the anterior portion of the orbit, although in the skull under description the facial sutures are badly damaged.

Frontals.—The frontals have a more anterior extent than in the Tapir. Their anterior prolongation is probably as far as the anterior orbital region. There was probably no articulation between the frontals and the ascending processes of the premaxillaries, as seen in the Carnivores. The frontals send down very large postorbital processes, but they do not meet the ascending process from the malar. It is impossible to determine the relation of the frontals to the bones of the lateral sphenoidal regions owing to the damaged condition of the skull. Posteriorly the frontals extend on a vertical line with the posterior inferior margin of the temporal fossa. The extension of the frontals posteriorly is the same as in the Tapir skull, and differs from the frontals of recent Carnivores where they extend to the middle of the temporal region.

Parietals.—The parietals form the largest part of the temporal fossa, but do not extend so far below as in the Tapir. Their surface is deeply concave and at the posterior part of the parieto-squamosal suture a number of postparietal foramina are present. In the Tapir's skull the parietals are prevented from articulating with the alisphenoids by the articulation of the squamosals with the frontals. The condition of the skull under consideration does not allow us to determine this point. At the posterior superior angle of the temporal fossa the edges of the parietals unite to form the very prominent sagittal crest which medially contains a deep groove. The sagittal crest only extends about one-third the length of the parietal roof before it diverges into the anterior temporal ridges already referred to.

Occipitals.—The supraoccipital region is triangular in outline, and bordered by the prominent lateral crests. Its surface above the foramen magnum is very prominent, and forms laterally strong ridges on each side for muscular attachments. Superiorly this region becomes concave and is not widely overhung by the lambdoidal crest. The most superior and posterior part of the temporal fossa is formed by a portion of the supraoccipital. This is a character common to the Tapir's skull but is absent from the skull of the Carnivores, (*Ursus*). The lateral extension of the exoccipitals is very great in this species, owing to the extreme width of this part of the occiput. The lateral part of the exoccipitals is bent slightly forward forming an angle with the median portion of the same. At the posterior inferior angle of the occiput the large paroccipital processes are given off. These processes in this species are quite different in form from those of recent Perissodactyles, and they approach those of *Rhinoceros* in form more nearly than those of the Tapir. The paroccipitals are very broad and heavy and they terminate below in a styloid process which probably did not extend beyond the condyles. The external borders of these processes come in contact with the post-tympanics of the squamosal. At the upper part of the junction of the paroccipitals and post-tympanics there is present in this skull a large foramen leading into the cranial cavity (paramastoid). The presence of this foramen is a constant character in the skull of the Tapir and Rhinoceros In *Equus* this foramen, if present, is not well expressed. In the *Dinocerata* the paramastoid foramen is present and is placed in nearly the same position as in *Palæosyops.*

The condyles in this species, as in all the other species of this genus, have a great transverse extent; viewed from the side they project much farther behind than in the Tapir's skull.

The portion of the occiput bearing the condyles is, as it were, much constricted from the occiput, thus producing the very prominent aspect of this part of the skull. The anterior and inferior ends of the condyles are separated by a longitudinal notch; but on each side a tongue-shaped process from the condyle extends a short distance upon the basioccipital. The foramen magnum is oval in outline and very long transversely. In the skull figured by Leidy, the foramen magnum has a much greater transverse extent than in that of the Tapir. The general form of this foramen resembles closely that of the Carnivores, being squarer in outline than in *Tapirus*, with its superior border deeply incised and bordered upon each side by two prominent convex processes abutting against the continuations of the exoccipitals. The basioccipital with the basisphenoid forms a broad triangular basal axis to the skull and their junction is on a line with the glenoid facets. The basioccipital is very broad posteriorly, the anterior portion having a very prominent median keel, bordered anteriorly and laterally by prominent rugosities. Laterally the surface of the bone is deeply excavated in a longitudinal direction. The lateral extension of this region is much greater than in the Tapir's skull. The basisphenoid is much narrower than the basioccipital and terminates on a line with the posterior opening of the alisphenoid canal. The posterior wing of the basisphenoid does not extend as far behind as in the Tapir's skull, and the portion of the alisphenoid between the glenoid and the alisphenoid canal is broader than in the latter.

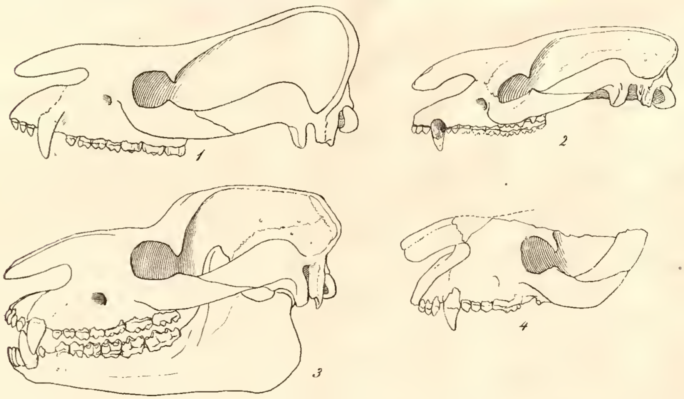


FIGURE 2.—Comparative view of the skulls of *Palæosyops* and *Limnohyops*. *1. Limnohyops laticeps*. *2. Palæosyops megarhinus*. *3. Palæosyops paludosus*. *4. Palæosyops lævidens*. One-sixth natural size.

Foramina—The condyloid foramen is distinct, and situated about an inch anterior to the condyles. It is placed at the most anterior portion of the bridge of bone connecting the basioccipitals. The anterior border of this foramen is very thin and easily broken through to the lateral vacuity. The large lateral vacuity upon each side of the basal region of the skull so characteristic of the Perissodactyles is very largely developed in this species. It is divided by the petrous bone, but the latter does not unite with the basioccipital, and consequently there is a communication between the fr. lacerum posterius and fr. lac. medium. A short distance in front of the vacuity and on a line with the glenoid cavity is situated the separate and distinct foramen ovale. This foramen in *Equus* and *Tapirus* has fused with the fr. lac. medium, although in some species of *Rhinoceros* the anterior portion of the lateral vacuity is separated by a deeply situated ridge of bone, dividing the foramen ovale from the fr. lac. medium. Just in front of and below the foramen ovale is placed the large posterior opening of the alisphenoid canal, but owing to the damaged condition of the specimen we must leave the description of this canal for another species.

Auditory region—The part of the squamosal bone forming the lower half of the temporal fossa is larger than in the Tapir. In the latter the squamoso-parietal suture is below the middle of the temporal fossa. In *P. paludosus* the suture is placed at about the middle of the fossa; its edges are much serrated. The course of this suture is slightly ascending as it approaches the anterior part of the fossa. The lower part of the squamosal overhanging the glenoid surface is bent strongly outward and is deeply concave. At the middle of this portion is a considerable foramen which is only slightly marked in the Tapir's skull. The zygomatic process of the squamosal is very strong and placed widely out from the side of the skull, much more so than any recent Perissodactyle. The portion of the zygoma between its origin and bend is deeply concave and looks forward; the posterior face of it is flat and looks backward and downward. The external face of the zygoma is placed obliquely and its surface is flat. The superior inferior extent of this part of the arch is very large, and it develops a large surface for the origin of the masseter muscle. The articulation of the zygomatic process and malar is very oblique and gradual. The postglenoid process is much elongated, with a distal rounded and rugose extremity. It is bent slightly backward and turned outward on its axis. The relation of the glenoid facet to the postglenoid process is very different in this species from that in the Tapir's skull. In *Tapirus* the postglenoid is strongly compressed and placed very obliquely to the glenoid facet. The latter is narrow and elongated. From the oblique position of these elements in the Tapir's skull, a deep triangular space is left between them; this space looks outward and backward.

In *Palæosyops paludosus*, owing to the more nearly parallel position of the glenoid and its process, this space is largely obliterated. In the Carnivores, where the postglenoid process borders the glenoid facet along its whole extent, this is still further the case. The glenoid facet in *P. paludosus* has very much the same form as in the Tapir, although it is more transversely elongated and shows no anteriorly directed portion. There is no sign of an internal glenoid process in the skull of this species. The post-tympanic process is much heavier than in the Tapir; its middle portion is compressed and distally it forms a club shaped extremity. The postglenoid and post-tympanic may nearly touch each other, although there is some variation in the relation of these two processes. The periotic is placed deep within the recess of the lateral space, its mastoid portion does not appear on the surface of the cranium, and its tympanic part was not ossified to the petrous portion.

Malar.—The form of the malar in this species is very characteristic, and it readily distinguishes it from *Telmatotherium*.

At the junction of the malar with the zygomatic process of the squamosal, it is strongly compressed and forms a broad lateral plate, strongly arched outward and slightly receding. The origin of the malar from the cheek is very gradual and not abrupt, as in some species of *Telmatotherium*. The form of the malar in this species differs from that of *P. megarhinus* in having no broad and shelf-like enlargement; its inferior margin is sharp, rough and slightly incurved. The margin of the malar forming the inferior rim of the orbit is thick and rounded. At the posterior inferior angle of the latter the malar is produced upward in a well marked post-orbital process.

Maxillary.—The form of the vertical plate of the maxillary in this species is more like that of the Carnivores than that of the recent Perissodactyles. This portion of the cheek is elongated, being longer than high. The portion between the malar insertion and the canine is flat and nearly vertical; its inferior margin, forming the alveolar border, is only slightly raised above the teeth. The superior part articulates largely with the nasals, which send down broad maxillary processes.

The articulation of the maxillary externally with the frontals in front of the orbit is probably very small. Anteriorly the vertical plates terminate in a very prominent portion, forming the canine alveolus. The superior internal border of the maxillary forms the upper half of the nasal notch. This margin is rounded and slightly concave, bordered above by the ascending nasal process of the maxillary. The situation of the infraorbital foramen is just in front of the malar insertion; it is large and not exposed, and corresponds in position with the anterior border of the first true molar.

The portion of the maxillary forming the floor of the orbit is short and broad; compared with that of *Telmatotherium* it is much less in its antero-posterior extent. In the recent Tapir the extension posteriorly of the alveolar portion of the maxillary is very great, but in *Rhinoceros* it is much less, and it is in about the same condition in the latter form as in *P. paludosus*. In the most specialized Artiodactyles where the orbit is placed far behind, the roof of the alveolar portion of the maxillary forms a small floor to the orbit, the large part of the orbit being opened widely below.

In *Palæosyops paludosus*, owing to the very short premaxillary region and consequent non-separation of the anterior premolars by a long diastema as in the Tapir, there has been no great drawing out of the alveolar region; and thus the roof of the alveolar portion of the maxillary is short, whereas in the Tapir, owing to the extreme length of the dental series, the alveolar border has been prolonged widely posteriorly.

The Palate.—The form of the palate in this species is very bear-like. It differs considerably from that of recent Perissodactyles, where the palatine region is strongly prolonged forwards and compressed. As in the Carnivores, the limit of the palate is bordered by teeth all around its circumference, there being no considerable interval in the dental series of *P. paludosus*.

In an example of a young specimen of this species in the collection, the palatal region is not coösified, and the two horizontal plates of the maxillary form a slight keel-like suture. As the palate is preserved as far as the posterior border of the first true molar, and it shows no signs of a transverse suture in its whole extent, we can safely conclude that the horizontal plates of the palatines formed only a very small portion of the palate, resembling in this respect the palate of the *Rhino-*

cerotidæ, where the palatines only form the extreme posterior border of the palate.

Mandible.—The form of the lower jaw of *P. paludosus* belongs to the less specialized type of mandible found so generally distributed among Eocene forms; that is, the portion bearing the teeth is more elongated than in recent forms, and the surface of the angular portion of the jaw is correspondingly enlarged for muscular attachment. The external face of the mandible is nearly flat, becoming slightly angular at the anterior border of the masseteric fossa. The inferior border of the jaw is slightly ascending from below the last molar. This portion is convex, becoming concave posteriorly, and then suddenly expanding into the wide and thin angle. The form of the inferior border of the jaw is very characteristic, and is quite different from that of *Telmatotherium* where the jaw is straighter, with a much more elongated symphysial portion. The posterior half of the lower margin of the jaw is strongly inflected; its internal face below the alveolar border is strongly convex, and the lower portion of this face thins out very much more than the upper part. The portion of the jaw inferior to the last molar is very large and its angle is strongly everted. The masseteric fossa is not strongly marked, and the internal pterygoid fossa is less developed than in the jaw of the Tapir. The middle portion of the ascending ramus is very much broader than in the Tapir's jaw, and the condyle is placed farther posteriorly from the coronoid processes than in the latter. The coronoid process is quite slender, elongated and separated from the condyles by a long, slender notch. The condyles are much broader transversely and heavier than those of the Tapir; they have also not the oblique position as in the latter form. The angular ridge limiting the masseteric fossa anteriorly and becoming continuous with the coronoid process above is very strongly developed in this mandible, much more so than in the Tapir's jaw. The ascending ramus of the jaw is much broader in proportion to its height than in the Tapir.

The symphysial portion of the mandible is broad and short; it differs considerably in form from that of the Tapir's jaw. The inferior margin below the premolars slopes gradually up to the incisor border, and presents no abrupt angle as seen in Suillines. The symphysis between the second and third premolars is not prolonged far beyond the canines for the insertion of the incisors. Thus this species differs very much from *Telmatotherium* in the characters of its symphysis, which in the latter genus is more Suilline and more horizontally placed than in *P. paludosus*. The mental foramen is situated below the second premolar and a smaller posterior one may be present.

Comparison with the Tapir's Skull.—From the foregoing description we may sum up the affinities and differences of the skull of *P. paludosus* as compared with that of *Tapirus*. 1.—In the nasal region there is little similarity between the two skulls, as the extremely highly specialized nasal region of the Tapir for the insertion of its large proboscis is entirely wanting in *Palæosyops paludosus*. We may add here that from the characters of the nasals of *P. paludosus* we may conclude that it probably had no proboscis, or if any, an extremely rudimentary one. 2.—The occipital region of the skull in both forms is closely similar, although the auditory processes and glenoid articulation are different. 3.—The elongated zygomatic fossa and the position of the orbit is similar in both forms. 4.—The orbital processes are more developed in *Palæosyops* than in *Tapirus*. 5.—The facial region of this species is quite different from that of the Tapir. 6.—The zygomatic arch is much stronger and more bear-like than in the Tapir'sskull. 7.—The separation of the foramen ovale from the foramen lacerum medium is different from that of the Tapir in which these two foramina are fused into one.

Skull Measurements.

	P. paludosus. M.	P. megarhinus M.	L. laticeps M.	P. lævidens. M.	T. cultridens. M.
Basal length of cranium	·420	·355	·420	– –	– –
Length from premaxillary to ant. border of orbit	·170	·125	·142	·125	·165
Vertical height of skull at ant. border of orbit	·084	·095	·082	·110	·105
Length from premaxillary suture to postglenoid	·345	·285	·370	·310	– –
Length of nasals	·125	·100	– –	– –	– –
Length of nasal notch	·115	·084	·112	·110	·125
Length of orbit	·035	·045	·050	0·45	·055
Length of floor of orbit at middle	·056	·064	– –	·054	·070
Length of temporal fossa	·200	·210	·225	– –	– –
Vertical height of temporal fossa at middle	·115	·100	·110	– –	– –
Anterior border of orbit to end of postglenoid process	·220	·160	– –	– –	– –
Greatest distance of zygoma from skull (one side)	·140	·092	·145	– –	·090
Height of occiput	·133	·105	·140	– –	– –
Width of occiput between post-tympanics	·165	·140	·210	– –	– –
Total width of condyles	·098	·098	·100	– –	·092
Width of foramen magnum	·043	·037	·030	– –	– –
Length of palate	·180	·155	·180	·180	·220
Width of palate between canines	·050	·045	·050	– –	·052
Breadth of skull between post-orbital processes	·135	– –	·150	– –	– –
Length of premaxillaries along palate	·034	·025	·042	– –	·053
Length of superior border of pre-maxillaries	·080	·065	– –	·068	·095

AXIAL SKELETON.

General Characters.—The collection of Princeton College contains a series of eleven vertebræ, which belong to this species. Of these there are three cervicals, six dorsals from the same individual, another dorsal from the posterior limit of this region, and lastly a lumbar, which is beautifully preserved, and shows interesting characters quite different from those of recent *Tapiridæ* or *Rhinocerotidæ*. There is also a fine specimen of the sacral region which probably belongs to this species. As most of the dorsals and lumbars are wanting, it will be impossible to give the exact number of the vertebræ of each region, but there are enough of the vertebræ of the subdivisions of the axial skeleton to characterize each. The vertebræ are unusually heavy compared to the rest of the skeleton, and their dimensions approach more nearly those of the Rhinoceros than those of the Tapir. The vertebral centra are characterized by their shortness and great depth compared to those of *Rhinoceros*. The great breadth of the transverse processes is striking. The lumbars on the other hand in contrast with those of *Rhinoceros* have deeper centras with rather high pedicles. The position and size of the articular processes in some regions of the vertebral column is quite different from that of recent Perissodactyles. The vertebræ of *P. paludosus* resemble those of the Rhinoceros as closely as those of the Tapir, except in the characters of the atlas, and as the vertebræ approach more nearly in size those of the Rhinoceros, I shall use the latter form for comparison.

Cervicals. (Pl. XIII, figs. 28–31.) The bodies of the cervicals are very deep and short, showing that this species had a short and thick neck. Their arches are not so much expanded as in *Rhinoceros*. In *Diplacodon* the deepening of the cervical centra is carried still farther, and with it a great compression of the body, making it very thin antero-posteriorly. In *Titanotherium* a greater breadth and thickness of the cervical centra is to be observed than in *Diplacodon*.

Atlas.—The atlas is very broad and heavy, much more so than in *Tapirus*. Its transverse processes are very wide and broadly extended, the articular cavities are extremely wide and very deep, being wider than this region is in *Rhinoceros*; but in contrast with the latter, the articular surfaces for the axis are much narrower, just reversing the dimensions of these two articular surfaces in *Rhinoceros*. Like that of the Tapir the atlas of *P. paludosus* exhibits two foramina for the first cervical nerve; the lower one, for the inferior branch of this nerve, being connected with the upper by a groove. In *Rhinoceros* the lower foramen is merely represented by a deep notch, but it is not enclosed as in this species. The transverse process of the atlas is perforated at its base by a large vertebrarterial canal, resembling in this respect the atlas of the Tapir. The floor of the neural arch shows a prominent tuberosity. The under surface of the atlas is smooth and rounded.

The Axis.—The general form of the axis, specimen No. 10,279, resembles closely that of the Rhinoceros. Its neural arch is very high and the spine is broad, high and deep. The neural spine is much higher than in the Rhinoceros; it projects more posteriorly than in that form, but its anterior extension is not as great. The postzygapophyses are larger and more nearly vertical than in *Rhinoceros*. The surface of the vertebra between the latter articulations is deeply excavated, thus forming a longitudinal groove which extends upon the surface of the spine. The centrum of the axis is very short; its posterior surface is slightly concave and very deep from above downwards. The under surface of the centrum is provided with a prominent keel, its surface being deeply excavated on each side of the latter. The keel is much longer and more prominent than in *Rhinoceros.* The anterior articular surface of the axis resembles closely that of the Rhinoceros. The odontoid process is very long and conical, much longer than in the Tapir. The articular surfaces for the atlas are much more oblique to each other than in the Rhinoceros. They are triangular in outline, their external portion being very broad, becoming narrow as they approach the middle of the vertebra. The neural canal of this vertebra has the same height as that of the Rhinoceros, but it is narrower, and the floor of the same has anteriorly a very conspicuous longitudinal tubercle. The axis of this species agrees with that of the Rhinoceros in not having interspinous foramina for the spinal nerves, which in *Tapirus* as in *Equus* come off from the spinal cord through a special foramen in the axis. The form of the transverse process of the axis is peculiar; it is placed higher than in *Rhinoceros,* its vertebrarterial canal being on a line with the upper surface of the body, and instead of the transverse process arising from the middle of the canal, it is placed above it, so that its inferior root is nearly vertical. This is certainly a very peculiar character of the vertebra.

Fourth cervical.—This is the only cervical vertebra posterior to the atlas which is preserved in the collection. Its most striking character is its high centrum, and this is apparently out of all proportion to the size of the arch. Compared with that of the cervical of the Rhinoceros the body is very much shorter; its height is about the same, but the breadth of the centrum is very much greater. This vertebra is slightly opisthocœlous, the anterior convexity being much less than in that of the Rhinoceros.

The anterior convexity, moreover, is marked by a transverse depression. The neural opening is slightly smaller than in *Rhinoceros.* The basal portion of the transverse process is pierced by a large vertebrarterial canal, and the diapophysis is much thinner and shorter than the parapophysis. The neural arch of this cervical is low and broad. The prezygapophyses are very large, and oblique and their inferior ends do not become concave as in those of the Rhinoceros. The peduncular portion of this cervical is lower than in that of the Rhinoceros. The postzygapophysis has been damaged in this vertebra. There is also in the collection a seventh cervical belonging to a smaller species than *P. paludosus.* This has the general form of the vertebra already described, its centrum is more opisthocœlous than the latter. The diapophysis only is present. The vertebrarterial canal is, as usual, wanting in this vertebra.

Dorsals, (No. 10,282.) Pl. XIII, figs. 32–35. There are six dorsal vertebræ in the collection in addition to the cervical last described, all belonging to the same individual. The most striking differences between this series of dorsals and the same vertebræ in *Rhinoceros,* are the dimensions of the centra and the great extension of the transverse processes. The centra of these vertebræ are nearly as convex anteriorly as those of *Rhinoceros*, but their posterior surface is less concave.

MEASUREMENTS OF VERTEBRÆ OF P. PALUDOSUS.

	M.
Atlas.	
Total width of atlas	·220
Width of ant. artic. processes	·112
Width of post.-artic. processes at middle	·100
Length at base of trans. process	·067
Diameter of neural canal	·048
Depth of atlas at middle	·070
Axis.	
Length of axis	·077
Elevation of spine above floor of centrum	·093
Length ant. post. along lamina	·063
Total breadth of ant. artic. surfaces	·106
4th Cervical.	
Length of body	·044
Height (total)	·047
Breadth of arch at ant. artic. processes	·082
Height of neural canal	·022
Length of bodies of six cervicals	·250

The first dorsal is lower and flatter than that of *Rhinoceros;* the pedicles are lower, and the height of its anterior articular processes above the centrum is not as great. The transverse process is longer and thicker from above downward than in *Rhinoceros*. The facets for the ribs look more anteriorly, whereas in the Rhinoceros. they look downward. The transverse diameter between the postzygapophyses is not as great in this species as in *Rhinoceros*, and the latter approach more nearly a horizontal than the latter form. The posterior capitular facets are more oblique to the plane of the centrum than in the Rhinoceros.

The notches for the spinal nerves are deep and open as in the vertebræ of the Rhinoceros, there being no perforation of the pedicles as in that of *Tapirus*. The characters of the second dorsal are about the same as those of *Rhinoceros*, viz: a decrease in height in the pedicles and change in slope of the prezygapophyses. The spine of this vertebra is very long and heavy, although shorter than that of the same vertebra in the Rhinoceros. It is deeply grooved in front.

The tubercular facet is horizontal in *Rhinoceros* and it looks more outward than in *Palæosyops*. The postzygapophyses are more oblique than in the first dorsal. In the third dorsal the transverse processes are finally preserved, they are broader and heavier than those of the Rhinoceros. The position of the tubercular facets is different from those of *Rhinoceros*. The lamina of this vertebra is quite short.

The intervertebral notches are much smaller than in *Rhinoceros*, the same being the case in all of the dorsals. The centrum of this vertebra has a prominent keel, the lateral surfaces on each side of the same being deeply excavated. The spine of the fourth dorsal is very oblique and elongated; its anterior edge is flat and grooved.

The width of the transverse process has diminished very much and it has become raised. These changes are likewise observed in the vertebræ of the Rhinoceros. In contrast with the latter form the tubercular facet far exceeds in size the capitular. It is deeply concave and looks downward and forward instead of outward as in *Rhinoceros*.

In the fifth dorsal the transverse processes are exceedingly short and have become very much raised. The tubercular facet has become flattened and looks more outward and downward. In this vertebra the two facets for the rib nearly approach each other in size; the body and pedicles have become higher as is usually the case. The post-zygapophyses are more elongated and horizontal than in the Rhinoceros.

In *Rhinoceros bicornis* in the 6–8 dorsal vertebræ the differentiation of the metapophysis from the diapophysis begins to appear. In *Palæosyops paludosus* this change is not well shown in the sixth dorsal, this being the last vertebra of this series preserved. The transverse process of the sixth dorsal is very short and heavy distally; its lamina is strongly triangular and raised. The anterior capitular and tubercular facets of this vertebra have nearly coalesced.

Posterior dorsal and anterior lumbar regions.—There are two vertebræ in the collection which belong to the posterior axial region. Their size agrees very closely with those already described as belonging to *P. paludosus*, and for that reason I shall refer them to this species. The characters of these vertebræ are highly interesting, as they depart widely in some respects from those of the recent Tapir and Rhinoceros, approaching more nearly those of *Equus*.

The most important difference is found in the pre- and postzygapophyses, and in the region of the lamina of the neural arch. The accessory processes are also more largely developed than in *Tapirus*.

Posterior dorsal.—This vertebra, No. 10,286, probably belongs to nearly one of the last of the dorsal series, as the position of its articular processes indicates. The peculiarities of this vertebra as compared with that of *Tapirus* and *Rhinoceros* pertain especially to the postzygapophyses, which in this species are much elongated and placed nearly vertical. In *Tapirus* and *Rhinoceros* the processes of the posterior dorsal region are obliquely placed and look downward and backward; it is only in the lumbar region that the postzygapophyses show a tendency to approach the vertical, but they never reach the position found in *Palæosyops*. In *Equus*, on the other hand, the posterior dorsal region has the posterior articular processes nearly vertical, but these processes in the lumbar region are not placed as vertically as in the dorsal region. Cuvier figures in a lumbar vertebra of *Palæotherium magnum* the same peculiarities in its postzygapophyses as in those of *P. paludosus*. The peduncular region of the vertebra in the former genus is very high and narrow; its transverse processes are short, with a flat and obliquely placed tubercular facet. The metapophyses in *Palæotherium* are well developed and connected with the transverse processes by sharp and high ridges. In the posterior dorsals of *P. paludosus* the prezygapophyses are concave, their external margin being slightly raised and bordered by the metapophysis instead of being oblique and with the surface plane as in *Rhinoceros*. In the form of these articular processes *P. paludosus* departs widely from the Rhinoceros, and, strange to say, in this character approaches the recent Horse.

The centrum of this vertebra is large and opisthocœlous.

Lumbar.—The characters of the lumbar vertebræ are very interesting and are widely different from those of the Tapir and Rhinoceros, and, like those of the dorsal already described, are decidedly Equine. The centrum is elongated and high; its anterior face is plane, the posterior being slightly concave. The body is keeled below and strongly triangular in outline. The neural arch is very high, narrow and much elongated; more so in proportion to its size than that of *Equus*. The diapophyses are broken off, but their bases are of good size. These processes were probably straight and rather narrow. The prezygapophyses are wide, being much wider and much less concave than those of the dorsals. The superior portion of this process exhibits no sign of convexity, as in the Artiodactyles, where the upper and lower articulations are convex and concave respectively. The prezygapophyses are bordered by the very prominent metapophyses, which are very large, compressed and extended half way across the surface of the lamina. They terminate in a rugose incurved extremity. The metapophyses in *P. paludosus* are very much larger than in any of the recent Perissodactyles. In the Tapir and Rhinoceros they are quite small. The neural spine is different in form and curvature from that of *Rhinoceros* and approaches in form that of *Equus*. The form of the postzygapophyses in the lumbar region is different from that of the dorsal just described. These processes are placed more nearly horizontal. In this vertebra we have a true interlocking of the articular surfaces, resembling that of the Artiodactyles but not as highly developed.

In contrast with the latter group the lower portion of the involute is very large and strongly convex, whereas the upper part joining the spine is very small and rudimentary. In the lumbars the basal portion of the episphen is developed. In comparison with the postzygapophysis of the last dorsal just described, we find the articular surface of this vertebra more complex; that is, the lumbar postzygapophyses are more highly developed than those of the dorsal region. In this respect *P. paludosus* resembles the Artiodactyles where the lumbar region reaches the highest complexity in its vertebral processes. The articular processes and the form of the neural arch of the dorsal and lumbar vertebræ just described differ so widely from those of the Tapir and Rhinoceros that it may be of interest to review the characters of these processes in recent and fossil Perissodactyles. *Palæosyops* shows its close affinity to *Diplacodon* in the characters of its lumbar vertebræ, in the latter form the neural arch and postzygapophysis having the same form as in the posterior dorsal region of *P. paludosus.* We have seen that at the posterior part the axial skeleton in this species departs widely from that of *Tapirus* and *Rhinoceros*; that it has strong Equine characters in the form of its articular processes, and also in the character of the neural arch. Cope mentions the fact that the pre- and postzygapophyses in *Hyrachyus* embrace each other as in the *Equidæ*, and the vertebræ are elongated and high as in *Palæosyops*. *Palæotherium* also agrees with *Palæosyops* in the form of its lumbar vertebræ, as in the former genus the articular processes are placed vertically. *Hyracotherium* approaches *Equus* in the form of the lumbar processes, as is shown in the following description by Cope :—[1]

"The remaining parts of the column (including dorsal and lumbar) show decided indications of Equine rather than Tapiroid affinity in two points; these are, first, the absence of isolated interspinous foramina, and second, the narrow form and more revolute articular surfaces of the postzygapophyses."

The large size of the metapophysis is a peculiarity of *Palæosyops* as compared to recent Perissodactyles, as in *Equus* these processes are larger in the posterior dorsal than in the lumbar region. In the Tapir and Rhinoceros on the other hand they reach their greatest size in the lumbar region, but they are very small comparatively.

Sacrum, No. 10,245.—The sacrum in this species is very long and narrow compared with that of *Rhinoceros.* It is made up of four coalesced vertebræ. The diapophyses are very short and compressed, those of the second being the largest and offering a large flat iliac surface. The diapophysis of the third sacral vertebra is also much flattened, so that the pelvis probably articulates with this vertebra. The intervertebral foramina are large.

The first sacral vertebra shows a much raised prezygapophysis, and in fact the vertical height of this part of the sacrum is greater than that of the Rhinoceros. The sacral diapophyses in this species have no articular surfaces for the lumbar vertebræ as they have in the Rhinoceros and Tapir. The extremely small size of the posterior face of the last sacral vertebra indicates that the tail was very short in this species, much more so than in *Rhinoceros,* where the body of the last sacral vertebra is quite large and broad.

The Ribs.—There are a number of portions of ribs in the collection, No. 10,281, all from the same individual, and as they are associated with the series of dorsal vertebræ which we have already described, I shall refer them to this species. The ribs are proportionately longer and narrower than in the Rhinoceros, and the width of their shafts is intermediate between those of the Rhinoceros and the Tapir. The shaft is characterized by its comparative thickness, and also by its external face being

[1]Tertiary Vertebrata. Page 627.

exceedingly rough for muscular attachment; this is particularly true of the portion of the shaft near the head, which is covered with a strong rugose prominence for muscles. The best preserved ribs in the collection are from the anterior thoracic region. In one proximal portion, which is one of the most anterior of the series, the head is separated by a long neck from the tuberculum. The facets of the head are continuous and not so obliquely placed to one another as in *Rhinoceros.* The tubercular facet is very large and forms a perfect semi-circle equally placed on both sides of the end of the shaft. In *Rhinoceros* this facet is limited more nearly to one side. Two other proximal portions of ribs in the collection, which are probably the fourth or fifth, show an approach of their proximal facets and, corresponding with the deeply excavated facet on the transverse process of the dorsal, the tubercular facet is very large, convex and placed nearly at right angles to the axis of the shaft. In the Rhinoceros on the other hand, the tubercular facet is perfectly flat and very obliquely placed. As with the more anterior ribs the fourth and fifth have the facets of the head in continuity. The total length of the shaft of the 5th rib was from ·40–·45 cm.

MEASUREMENTS OF VERTEBRÆ OF P. PALUDOSUS—*Continued.*

	M.
Dorsals.	
Length of body of 1st dorsal	·040
Height of body of 1st dorsal	·047
Width of transverse processes	·170
Elevation of spine of 3rd dorsal	·150
Width trans. proc. of 3rd dorsal	·130
Width of posterior articular proc. of same	·052
Length of spine of 5th dorsal above body	·115
Length of transverse processes	·104
Dorsal No. 10,286.	
Length of body	·047
Total width of ant. artic. processes	·037
Length along lamina	·063
Vertical height of post. artic. processes	·023
Lumbar No. 10,278.	
Length of body	·051
Length of lamina including artic. proc.	·074
Height of post. artic. proc. above body	·035
Total width of anterior artic. proc.	·042
Length of metapophyses	·032
Sacrum No. 10,245.	
Total length	·150
Greatest width anteriorly	.112
Width of centrum in front	·045
Width of centrum behind	·015
Greatest vertical height	.070

Appendicular Skeleton.

Scapula. (Pl. XIII, figs. 37, 38).—There are a number of fragments of scapulæ in the collection, the best example being No. 10,277, which I refer to this species. Only the lower half of the scapula is well preserved, the suprascapular region being wanting. The part preserved is characterized by its breadth and massiveness. The glenoid cavity is deeply concave from before backward and anteriorly it is limited by the hook-like projection of the anterior border. Viewed from below, the outline of the glenoid is very different from that of *Tapirus* and more closely resembles that of *Rhinoceros.* In the latter form the outline of the glenoid is a broad oval, being about equal at both ends. In *Tapirus Indicus* the middle dimension of the glenoid is the greatest, whereas in *P. paludosus* it forms an elongated oval. The coracoid process in this species is rather short, stout and strongly recurved; internally it is separated from the glenoid border by a deep notch. The form of this part of the scapula is very different from that of recent Perissodactyles, where the coracoid is not separated from the glenoid border by an interval as in the Rhinoceros, but rises directly from it. In recent Perissodactyles the coracoid is separated from the glenoid border by quite a long interval; in the Tapir and Rhinoceros this process is short, and is not incurved.

Equus has a small and incurved coracoid process. The anterior border of the scapula in *P. paludosus* is thin and concave above this process; then it becomes strongly convex, its superior border having been probably rounded and convex as in *Rhinoceros.* The anterior border is not divided by a coraco-scapular notch as in the Tapir and some species of Rhinoceros. The posterior border is slightly concave and probably formed a rounded angle with the suprascapula border.

At the lower part of the posterior border, and separated from the glenoid by a slight notch, is a large rugose tuberosity. This is oval in outline and forms a prominent character in the scapula of this species. In the Tapir and Rhinoceros this tuberosity is wanting. The neck of the scapula is only slightly marked off, and is concave on each side below the origin of the spine. The spine arises on a line with the upper end of the tuberosity; at its origin it is very broad and heavy. The spine forms a right angle with the glenoid cavity.

From the scapula of a form closely allied to *Palæosyops,* in which the spine is provided with a recurved process, I conclude that in this species the scapula spine was also thus provided. The internal face of the scapula is nearly smooth, showing only a slight longitudinal convexity. In comparison with that of the Tapir the whole plane of the scapula is strongly incurved.

Humerus, No. 10,373.—There is in the collection only a distal part of a humerus which I can refer to this species. This humerus was not associated with the rest of the skeleton of *P. paludosus,* but was found in the same locality. The distal portion represents probably about one-half of its entire length. The shaft of the bone is unusually heavy compared with that of the allied genus *Limnohyops.* The upper portion shows the distal prolongation of the deltoid ridge, which in this specimen is very thick, heavy and strongly bent outwards. The posterior face of the shaft is convex, and below the origin of the deltoid ridge it spreads out widely, its distal portion being very massive. The supinator ridge is prominent. The external condyle is flattened just above the trochlear, but above and below it thins out to a prominent process.

The upper process limiting the upward prolongation of the external trochlear is especially prominent. The trochlear surface itself is very broad and heavy, its general form resembling that in *Limnohyops*. The internal division of the trochlear is limited by a more downward projecting process than in *Limnohyops*. The external trochlear is also more rounded than in the latter genus, with the median keel not so sharply defined. The interval between the two trochlears is wider and rounder than in *Limnohyops*. The supra-trochlear and anconeal fossæ are large, but there is no foramen present, agreeing in this respect with the humerus of *L. laticeps*.

Radius, (No. 10,282). Plate XII, figs. 21, 22.—The identification of the distal portion of this radius is certain, as it was found associated with the other portions of the skeleton, including teeth which belong to this species. It is slightly crushed, making the articular surface appear unusually wide; the distal portion is fully one-half wider than in *Limnohyops*. The portion of the shaft preserved is also wide and heavy, showing that it belonged to a very heavy forearm. The character of the articular surface offers no very striking peculiarity. The scaphoid portion of this articular surface takes up a considerable space posteriorly. It is more prolonged vertically on the shaft of the radius than in allied forms, thus giving the forearm more fore and aft play than in the more lightly constructed arm of *Limnohyops*.

The Manus, (Pl. XIV, fig. 45).—The carpus of this species, which is figured, is a composition, and is derived from a well preserved lunar, which was associated with other parts of skeleton, No. 10,282. The remaining elements of the carpus were not found associated with this skeleton. The carpus is characterized by being very broad and heavy; its transverse axis is about twice that of the vertical, differing in this respect from *Tapirus* and *Hyrachyus*, in which the height of the carpus more nearly coincides with its breadth.

The fifth metacarpal in *P. paludosus* is large and not as much reduced as in the Tapir. Owing to the large size of metacarpal V the mesaxial line of the carpus passes between metacarpals III and IV, presenting the arrangement found in *Titanotherium* (*Paraxonia*). In the Tapir, on the other hand, metacarpal III is very much larger than the other metapodials and consequently the axial line of the manus passes through that digit.

The metapodials of *P. paludosus* are heavy and wide spreading, being short in comparison to their breadth. The carpal elements are broad, short and their relations to each other are quite different from those of recent forms, differing radically from the Tapir and approaching more nearly the character of *Titanotherium*, but also showing some Rhinocerotic affinities. The shape of the lunar and unciform, with their facets, is very characteristic of this species. The division of the carpal elements equally by the inferior process of the lunar is not so strongly marked as in some other genus of the family, (*Limnohyops.*)

Scaphoid.—The scaphoid is a very broad and exceedingly heavy bone. Its superior facet is plane, very large and not bordered by prominent processes as seen in that of the Rhinoceros. The inferior facets of the scaphoid are very oblique to each other. The scapho-magnum facet occupies all the superior face of the magnum. The scapho-trapezoid facet is very long from before backward, deeply excavated, and its anterior portion rises upon the anterior face of the bone. There is a very small facet for the trapezium in this specimen. The beak of the scaphoid is not so widely prolonged ectally as in *Rhinoceros,* being in about the same progress of displacement as in *Tapirus.*

Lunar.—The form of the lunar is very characteristic in this species. It is remarkable for its massiveness and breadth as compared with that of *Limnohyops.* The posterior prolongation of the lunar between the magnum and unciform is not as great as in the latter genus, but rather more so than in *Titanotherium.* Its transverse diameter along the superior surface is nearly equal to its vertical. From before backward the lunar in this species is deep and is not provided with a posterior hook-like process. The superior facet of the lunar is separated medially by a deep concavity dividing the face into an anterior and posterior portion; the latter is high and convex and slopes abruptly backward as in *Tapirus* and *Rhinoceros.* The inferior facets of the lunar are unequal in size, the lunar unciform taking up about two-thirds of this face. This facet is deeply concave from before backward, and is separated from the lunar-cuneiform facet by a slight ridge. The lunar magnum facet is very characteristic of this species, its plane of articulation, as it were, having been rotated anteriorly, thus exposing it to view when looked at from the front. It is very oblique to the facet of the opposite side, and it curves upward and backward to become continuous with the lunar-scaphoid facet. In form and general relations the lunar in this species approaches more closely to that of *Titanotherium* than to the lunars of other forms studied by the author. The lunar of *P. paludosus* is easily distinguished from that of *Hyrachyus,* in which its form is very high and narrow with the lunar magnum facet placed widely to the outside and nearly vertical.

Cuneiform.—The cuneiform is quadrangular in form, being very broad and low. Its shape differs very much from the cuneiform of *Tapirus* and *Hyrachyus* where this bone is high, narrow and slopes abruptly away from its radial angle. Owing to its form the cuneiform in *P. paludosus* offers a very long superior facet for the ulna. This facet is very extensive transversely and shallow from before backward. The cuneiform-pisiform facet is placed high up and posteriorly, the pisiform not appearing upon the anterior aspect of the carpus. In *Tapirus* the cuneiform-pisiform articulation is seen conspicuously upon viewing the carpus from the front. The cuneiform-unciform facet is triangular in outline, the widest portion being internal. The surface of this facet is slightly concave and articulates obliquely with the unciform. The trapezium is wanting in this carpus.

Trapezoid.—The trapezoid is deep from before backward, being triangular in outline. Its external facet is very oblique for articulation with the magnum. The anterior face of the trapezoid is broad and low, differing thus from *Tapirus* and *Hyrachyus*, where the vertical axis of the bone is greater than the transverse. The trapezoid-metacarpal II facet is deeply convex from side to side. The internal face of the trapezoid exhibits a large facet for the trapezium.

Magnum.—The anterior face of the magnum in *P. paludosus* is pentagonal in outline, being very broad transversely. The form of this bone differs radically from that of *Limnohyops*, in which it is much higher and narrower than in this species, thus resembling *Hyrachyus* which has also a high, narrow magnum. The magnum in *P. paludosus* resembles closely that of *Titanotherium*, as its general form and arrangement of the facets are nearly the same as in that genus.

The relations of the magnum to the other bones of the carpus in this species are very different from those of recent forms, and when we compare its position in the carpus of *Tapirus* with its place in *Palæosyops*, the striking difference in its size and plane of articulation is apparent. The plane of the magnum-scaphoid facet is very oblique, being broad in front and narrowing posteriorly as it ascends upon the pivot of the bone; it is taken up entirely by the scaphoid, offering no articulation for the lunar. The external face of the magnum forms a right angle with its superior face. The anterior part of the external face is perfectly plane, and is subdivided equally for the lunar and unciform. Thus the magnum and unciform have quite a broad surface of contact anteriorly, which is very much reduced in *Limnohyops*. In *Titanotherium* we find about the same relations between these three carpal elements as in this species. In *Tapirus* on the contrary, the external facet of the magnum is wholly taken up by the unciform; and the lunar being crowded out, as it were, from this articulation presents a nearly plane surface of contact for the magnum and unciform. The articulation of the magnum-metacarpal III facet in this species is triangular in outline. This articulation is placed rather obliquely and internally and is produced by the large facet developed on metacarpal III for the unciform. The magnum-metacarpal II facet is narrow and produced far posteriorly. It forms an angle with that for the trapezoid. The pivot of the magnum is very strongly developed in this species and rises high above the plane of the anterior face.

Unciform.—The unciform is another characteristic bone in the carpus of this species. It is very heavy, with a long transverse diameter. Its vertical axis is equal to about one-half the transverse. The shape of the unciform differs very much from that of *Tapirus* and *Rhinoceros*, as in these forms the transverse axis is rotated more to coincide with the vertical than in *P. paludosus*, thus producing a wide unciform-magnum surface for articulation.

The extensive transverse breadth of the unciform prolongs its articulation with the magnum nearly to the median axis of metacarpal III.

The superior facet of the unciform is obliquely placed and concave from side to side; it is rather shallow from behind forward and limited by the posterior tuberosity of the bone. This tuberosity is placed externally and curves outward instead of downward as in the Rhinoceros. The unciform-lunar facet is large, very oblique, and forms a wide angle with the superior facet for the cuneiform. The unciform-magnum facet is small, only allowing about one-third of the internal surface of the bone to articulate with the magnum. This contact in *P. paludosus* is much larger than in *Limnohyops*. Comparing this facet with that of the Tapir and the Rhinoceros we remark their great difference. In the latter form the unciform has a large and more nearly vertical facet for the magnum which is very extensive and extends all across the articular face of the bone. The facet for metacarpal III is large, more so in proportion than in the Tapir, and nearer horizontal. The inferior surface of the unciform is deeply concave from before backward, and is subdivided slightly for the two lateral digits of the manus. Owing to the large transverse extent of the unciform, the facet for metacarpal V is large, and this digit is not placed so far to the side and behind as in the Tapir, in which the fifth metacarpal is smaller than in *P. paludosus*.

The inferior face of the unciform is not prolonged beyond the magnum like that of *Tapirus* but is nearly on the same horizontal line with it. In fact a horizontal line drawn beneath the magnum would limit the carpus distally.

Pelvis, No. 10,232.—The pelvis in *P. paludosus* is short and broad and its general proportions approach very nearly those of *Rhinoceros*. It agrees with the latter form in having the iliac portion longer than the ischial, although in this species the ischia are longer proportionately to the ilia than in the Rhinoceros. The total length of the os innominata compared with the expansion of the ilia is greater in this species than in the Rhinoceros.

Diplacodon differs from *Palæosyops* in having a pelvis much longer and narrower in comparison to its breadth. The external border in *Diplacodon* is shorter and the plane of the gluteal surface is thrown more outward than in *Palæosyops*.

Ilium.—The ilia are flat and thin with their external angles inverted. The supra-iliac border is not interrupted by a depression as in the pelvis of the Tapir but forms a strongly convex border pointing forward and outward. The ischial border tapers gradually below and then becomes strongly convex superiorly, where it joins the supra-iliac border to form the sacral portion, the latter being much like that of *Rhinoceros* in form. The external or acetabular border is rather long and deeply concave; it forms with the supra-iliac border a sharp angle. The peduncular portion of this border is rounded and terminates at the rim of the acetabulum in a prominent triangular tuberosity for the rectus muscle.

The proximal portion of the pubic border is very prominent, producing in this portion of the pelvis a strongly triangular section. At the distal part of the neck this border disappears. The neck is long and very broad compared with the other pelvic dimensions. It is longer and rises more gradually from the acetabulum than in the Rhinoceros; its section is triangular, being flat externally and subdivided internally by the pubic border.

Above and below the neck is thin, with the basal portion of the same very heavy, owing to the presence of the large rectus tuberosity. The acetabulum is much longer than high; its anterior and superior rim is very prominent, being limited anteriorly by a well defined anterior border. The depression for the ligamentum teres is very long and narrow and penetrates half way across the surface of the acetabulum. The acetabulum of this species differs in form from that of the Rhinoceros. In the latter it is very high and narrow with only a slight depression for the ligament.

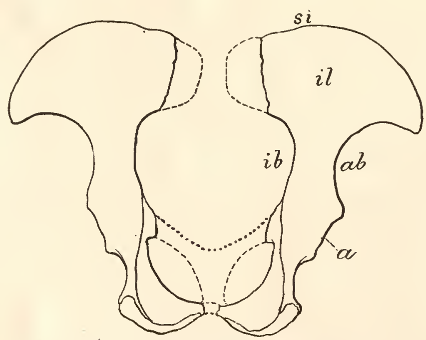


FIGURE 3.—Pelvis of *Palæosyops paludosus*; one-sixth natural size. *Si, ib, ab*, borders of the ilium; *a*, acetabulum; *il*, ilium.

Ischium.—The ischial division of the pelvis is short; its border above the acetabulum exhibits a slight spine roughened at its basal portion. There is no decided ischial notch as in the Rhinoceros. In the latter this tuberosity is very prominent and triangular in outline. The middle part of the ischium is triangular in section. The neck tapers gradually to the ischial tuberosity, which is very different in form from that of the Rhinoceros. This portion of the ischium in *P. paludosus* forms a broad plate, rounded at the extremity, with the tuberosity not constricted off as in the Rhinoceros. The ischial plate becomes thin as it approaches the symphysis, and is limited behind by a strongly convex border. The lower portion of the ischium and also all of the pubis are wanting in this specimen. The broken extremity of the ischium is very small, and probably the ischiæ formed but a small part of the symphysis. The obturator foramen in this species is oval in outline, being larger and not as broad as the same foramen in the

Rhinoceros. The angle formed by the inferior elements of the pelvis was probably more acute than in the Rhinoceros, as in *P. paludosus* the ischial part of the pelvis is longer. We see from the above description that the pelvis of *Palæosyops paludosus* is very different in outline from that of the recent Tapir which is elongated, with a triradiate iliac portion. The dimensions of the ischia are very long compared with those of the ilia in this species and approach more nearly those of *Titanotherium.* We should hardly expect to find the pelvis so elongated in an intermediate form like that of *Diplacodon,* but we have seen that the diameter of the tarsus of the latter is also elongated and higher than in *Palæosyops.*

MEASUREMENTS OF PELVIS No. 10,232—P. PALUDOSUS

	M.
Total length of innominate bone	·415
Length of ilium from middle of acetabulum	·270
Width of crest of ilium	·265
Width of peduncle	·060
Length of ischium from middle of acetabulum	·155
Width of ischium behind	.090
Length of acetabulum	·063

Femur, No. 10,282.—There is in the collection of Princeton College a posterior extremity of *P. paludosus,* including a femur, tibia and the proximal portion of the tarsus, all belonging to the same individual. The femur is very much crushed and consequently abnormally elongated, and we shall therefore take our description largely from other portions of femora belonging to the same species. Leidy has figured a femur[1] which he refers to the smaller species of *Palæosyops.* This specimen is in the Museum of the Academy of Natural Sciences of Philadelphia and it is unusually well preserved. After having studied this femur and taken comparative measurements of it, I believe that it was incorrectly referred by Leidy to *P. minor.* It should have been referred to the species under consideration. The femur of this species is very much like that of the Tapir in its general characters, but its proportions are altogether longer and broader. The head is round and placed well to the side as in the Tapir. The depression for the ligamentum teres is placed nearer the centre of the head than in the latter animal. A slightly constricted neck separates the head from the shaft. The region between the head and the trochanter is very broad and heavy, and is compressed and narrow.

The great trochanter is very large and extends from before backward for some distance; its posterior process is strongly recurved and rises somewhat above the head of the bone. The distance between the anterior and posterior tuberosities of the great trochanter is considerable. This portion is strongly concave and is bordered externally by a prominent crest. The anterior tuberosity of the same is very prominent and strongly rugose. The form of the great trochanter in *Palæosyops* is very different from that of the Tapir where the posterior tuberosity is much higher

[1]Extinct Vertebrata, etc. Plate xxix, Fig. 5.

than the head, and the anterior one is much reduced. The fossa between the two divisions of the trochanter is absent in *Tapirus*. An exaggerated form of the great trochanter of *P. paludosus* is seen in *Equus*, but in the latter form the posterior hook-like process is placed nearer the head than in *P. paludosus*. The trochanteric fossa is deep, broad, and bordered externally by the prominent rim of the great trochanter.

The anterior surface of the shaft below the head is strongly triangular in outline, becoming deeply concave at each side and above the lesser and third trochanters. The anterior surface of the shaft below the trochanters is strongly convex and its surface narrows below the third trochanter. The lesser trochanter is prominent, compressed and very much elongated; it extends posteriorly to a horizontal line cutting the third trochanter near its middle. The third trochanter in its large size is in strong contrast to that of the Tapir, where it is very much smaller than in *Palæosyops*. The third trochanter is placed at about one-third the length of the shaft from the head; it is long, flat and not as prominent as in the smaller species of the genus; its position in the Tapir is nearer the middle of the shaft. In *Rhinoceros* we see a wide variation from the above form in the position of this trochanter, which is placed at about the middle of the shaft.

The distal extremity of the femur in this species is unusually heavy and broad, very much more so than in that of the Tapir. The trochlear surface is narrow and long. The internal ridge of the trochlear is more elongate and prominent than the external. Posteriorly the trochlear surface becomes continuous with the condyles, the latter being heavy and extending some distance backward. The intercondylar notch is long and very deep. The tuberosities are prominent; the surface between them and the trochlear is convex instead of concave as in *Tapirus*.

The posterior face of the shaft presents a number of differences distinguishing it from that of the Tapir; the lower portion is very broad and flat and resembles in this respect the shaft of the femur in the Rhinoceros. In the Tapir and in the Equine series the posterior external border of the shaft of the femur presents a deep fossa for the flexor perforatus muscle. In *Palæosyops* this fossa is entirely absent, and as in *Rhinoceros*, the surface for the origin of this muscle is flat and slightly rugose, somewhat more so than in the latter.

Patella, No. 10,282.—The patella is narrower and much more elongated than in the Tapir. Superiorly it is rounded and shows no projecting processes; the inferior end is pointed. The anterior enlargement of the patella is slightly curved outward. Its internal articular surface is long and narrow, with the external articular portion broader than the internal.

Tibia, No. 10,282.—The tibia of this species is more slender and rather longer than in *Rhinoceros bicornis*. The femur on the other hand in *Rhinoceros* is longer than the same bone in *P. paludosus*. The upper articular surface of the tibia is much broader transversely in comparison to the antero-posterior diameter, whereas in the Rhinoceros these diameters more nearly approach each other.

The superior external facet is also long proportionately, the internal facet being much shorter and rounder. The crest of the tibia is very prominent and heavy; its tuberosity is broad, bevelled off and shows no subdivision like that of the Rhinoceros and Tapir. The superior external border of the tibia is not incised as in the Tapir for the transmission of the tendon of the anterior extensor. This notch is only slightly marked in *Rhinoceros*. In the Equine series the notch for the extensor tendon is very strongly marked, especially so in the recent Horse. The longitudinal fossæ of the upper portion of the shaft are strongly developed and deep. The middle section of the shaft is flattened, thus reducing the diameter of the internal border of the bone. The distal extremity of the tibia is broad and flattened. The trochleæ are shallow, the external border of the outer being deeply excavated for the fibula. The posterior trochlear tuberosity is short and not prominent. The superior contact of the fibula and tibia forms quite a deep depression, and the tibia shows a distinct flat facet for articulation with the fibula. In the Rhinoceros this facet for the fibula is absent.

Tarsus. (Pl. XIV, figs. 46–49).—There is an abundance of material in the collection pertaining to the pes of this species, and, moreover, an astragalus and a calcaneum are associated with the posterior extremity already referred to, so there is no doubt as to the correct identification of the tarsus. The figure of the foot is a composition, the tarsal elements, other than the astragalus and calcaneum, not having been found with the extremity above mentioned. The foot of *P. paludosus* as compared with that of *P. minor* and *Limnohyops* is very much heavier, being broader and longer. The form and arrangement of the tarsal facets are quite different from those of the related species and approach more nearly the condition found in *Diplacodon*, although in the latter genus some of the facets are the reverse in size of those of *P. paludosus*. Compared with the recent Perissodactyles, such as the Tapir, we notice a great change in the size and arrangement of the tarsal elements, and in order to make the description clearer, I shall enumerate some of the most important variations in the tarsus of this species as compared with that of *Tapirus*. The most striking difference between the two tarsi pertain to the ectocuneiform and its facets. In *P. paludosus* this bone is very high and narrow and the proximal portion of metatarsal IV is likewise narrowed, consequently there is no articulation between the latter and the ectocuneiform; in other words, the reverse type of tarso-metatarsal articulation does not occur in this species as it does in *Tapirus indicus*. The cuboid moreover, has a slight contact with metatarsal III. The astragalo-cuboid facet is very large. The articular faces of the tarsal bones are flatter than in the tarsus of the Tapir. And lastly there is not so decided a difference in size between metatarsal III and the lateral metatarsals as in the Tapir.

Calcaneum.—The calcaneum in this species is short and broad. Its articular portion is particularly massive. The tuber is short, the distal part of the same being club-shaped and very rugose. The neck of the calcaneum is slightly compressed, with a considerable depth. All the facets of the calcaneum are widely separated. The ectal facet is very large, convex, and sends a narrow tongue-shaped portion anteriorly. The ectal facet may articulate posteriorly with the tibia, although this is a marked exception to the rule, as generally the astragalus extends too far behind for such an articulation, (tarsus No. 10,282 shows a slight exposure of the ectal facet of the calcaneum for the tibia.) A fibulo-calcaneum facet may be present, although in some specimens it is not well shown.

Three out of five calcanea of this species in the collection exhibit a fibular facet. The sustentacular facet is very large. It is oval in form and slightly bent toward the cuboid side. This facet is widely separated from the inferior. The size of the sustentacular facet may vary considerably, being in some cases short and broad, or it may be more elongate than usual. The inferior facet of the calcaneum is well marked. It is rather elongate and narrow. It extends about half way across the anterior border of the bone and is not separated by a ridge from the cuboid facet. The position of the inferior facet is very oblique. The calcaneo-cuboid facet is large and deeply concave from above downward. Its middle portion transversely is nearly plane. This facet is bordered externally by a rounded margin and internally by a straight border which terminates above in a prominent process. A longitudinal fossa separates the sustentacular from the ectal facet of the calcaneum and corresponds with the depression upon the astragalus, whereby a long, narrow opening is produced when the two bones are in juxtaposition. This fossa is very large in *Titanotherium.*

Astragalus.—The astragalus is relatively short and broad; its trochlear surface is broad and low. The external trochlear is bordered by a prominent, incurved, flat process, which is a continuation of its anterior margin. Posterior to the insertion of this process upon the internal side of the trochlear there is a deep fossa. The antero-posterior diameter of the two trochleæ are generally equal, but in some specimens the external may be excavated behind to allow of the contact between the tibia and calcaneum. The facets of the inferior surface of the astragalus are separated, the inferior especially being widely isolated from the sustentacular.

The ectal facet is very large and deep, and it sends a narrow portion anteriorly. The antero-posterior diameter of this facet is much greater than the transverse. The sustentacular facet is large and extends to the anterior face of the astragalus; it there abuts against the cuboid facet, being separated from the latter by a slight ridge. The inferior facet of the astragalus is characteristic, as it is small and widely separated from the sustentaculum. The inferior facet only takes up about one-third of the whole cuboid border of the bone. We shall see later that in the forms related to *P. paludosus* the inferior facet is much larger, as is the case with *Diplacodon,* where the sustentaculum is reduced and the inferior facet larger than in *P. paludosus.* The section of the anterior face of the astragalus is triangular, the apex of the triangle being formed by a narrowing of the bone at the junction of the sustentacular with the cuboidal facet. The latter facet forms an angle with the navicular face greater than 90 degrees. In *Hyrachyus* and the smaller species of *Palæosyops* the cuboid facet is more sharply separated from the navicular than in *P. paludosus*. The cuboid facet of the astragalus is large and takes up nearly one-third of the anterior face of the bone. Strange to say, in *Diplacodon*, where we should expect to find this facet still larger, such is not the case, the astragalus of this genus figured by Scott and Osborn in their Uinta Mammalia being really not as large compared with the breadth of the whole face of the bone as in *P. paludosus*.

	Whole face.	Cuboid facet.
	M.	M.
Diplacodon–	.060	.015–
P. paludosus–	.050	.015–

Navicular.—The navicular in *P. paludosus* resembles very closely that of the Tapir. It is a flat and very low bone and rather deep; its proximal surface is bordered externally by a prominent raised process as in *Tapirus*. The distal articular face of the navicular is subdivided differently from that of the Tapir. Owing to the small size of the ectocunciform, the facet for this bone upon the navicular is not much larger than that for the mesocuneiform, although the facet for the latter is not as deep as that for the ectocuneiform.

Ectocuneiform.—The ectocuneiform in this species is a much narrower and higher bone than that of the Tapir. In *Hyrachyus* we see the breadth in comparison to the height still more reduced than in *P. paludosus*. The narrowness and great depth are the most important characters of this bone in *P. paludosus*. Both articular faces are nearly plane, the upper one being slightly concave. On the external side the ectocuneiform shows a single large facet for the cuboid and, internally, two separated facets for metatarsal II. The articulation of metatarsal II and the ectocuneiform is quite different from that in *Tapirus*. In *P. paludosus* this metapodial overhangs, as it were, the upper surface of metatarsal III, and thus the ectocuneiform does not pass beyond the articulating surface of this metatarsal as it does in the tarsus of the Tapir.

Mesocuneiform.—This cuneiform is much larger in *P. paludosus* than in the Tapir, and consequently there is not as great a difference in size between the two internal cuneiforms as in the tarsus of the Tapir. This bone is triangular in outline, being broad in front and narrow behind; its external side presents an oblique surface outward, and internally there is apparently no facet for the entocuneiform, although this facet is displayed by the navicular.

Cuboid, No. 10.288.—The cuboid is compressed and very deep; its external surface is concave, being bordered anteriorly and posteriorly by the prominent raised edges of the bone. The inferior surface of the cuboid is provided with a deep, narrow and very prominent tuberosity which is median in position. The form of the cuboid is quite unlike that of *P. minor*. In the latter species this bone has nearly a square form with very much less depth than in *P. paludosus*. The in the articular surfaces of the cuboid in the smaller species are also much flatter than latter. The tuberosity of the cuboid in *P. minor* is not so narrow and elongated as in the larger species. The subdivisions of the proximal face of the cuboid in *P. paludosus* are not well marked. The calcaneal portion is very deep and slightly convex from side to side; the astragalar facet is elongate and narrow, larger above than below and concave from above downward. The facets for the navicular and ectocuneiform are short and deep; they are quite different in form from those of the smaller species. The cuboid-ectocuneiform facet is much larger than the facet for the navicular. The distal face of the cuboid in *P. paludosus* is much deeper than broad; its posterior portion is narrower than the anterior. The surface of this facet is plane and slightly oblique. The inferior internal angle of this cuboid exhibits a small truncated facet for metatarsal III. Another cuboid in the collection does not show any facet for this metapodial (No. 10,282).

Metatarsals.—The metatarsal region of *P. paludosus* is short, with the digits wide-spreading. The metatarsal III is slightly larger and broader than the lateral metapodials, but does not show the difference in size that is seen in the foot of *Palæotherium*, for example. The proximal portion of metatarsal II is broad, with the external side abruptly truncated. A peculiarity of this metatarsal is that it shows no facet for the entocuneiform such as occurs in *Limnohyops*. Its articular face for the ectocuneiform exhibits two round separated facets. The distal extremity of this metatarsal is heavy, with prominent tuberosities bordering the articular surfaces. The upper part of metatarsal III is very narrow compared with its distal portion. The surface for the ectocuneiform is nearly flat and obliquely placed; its cuboidal sides show two facets for metatarsal IV. The distal part of metatarsal III is extremely heavy and its articular surface is wide and subdivided posteriorly by a prominent keel.

Metatarsal IV is strongly concave on its external side and its shaft is much heavier than that of metatarsal II; its superior face is unusually flat, being broad and shallow. The metatarsals in *P. paludosus* resemble closely those of the smaller species of the genus, the difference being largely in their heaviness and the size of their articulating surfaces.

Summary of the Characters and Affinities of the Skeleton of Palæosyops paludosus.

In the foregoing chapters I have described the bones of the skeleton of this animal and compared them with those of recent and fossil Perissodactyles, and I now propose, as briefly as possible, to sum up the principal characters of the skeleton, and to compare its peculiarities with those of allied forms.

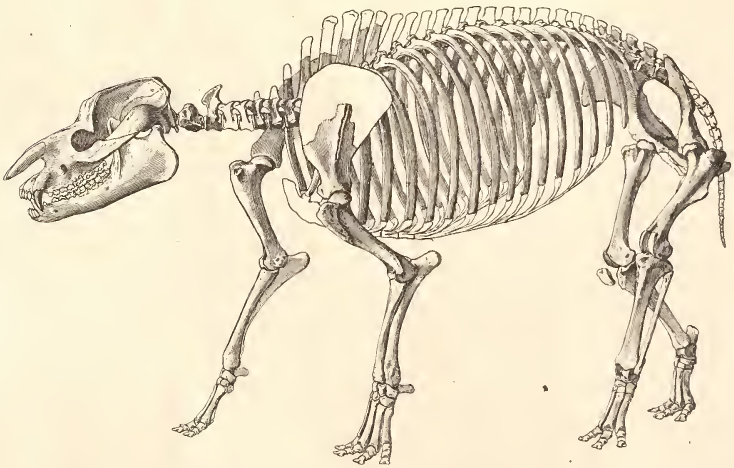
Certain characters are found in the vertebral column which depart widely from those of the Tapir. These are the form and position of the articular processes of the posterior axial region. It was also observed that among recent forms the Horse approaches *Palæosyops* more nearly than any other existing Perissodactyle in the position of its lumbar processes.

Palæosyops shows its closer affinity to *Tapirus* than to *Rhinoceros* in the foramina of its atlas. The large size of the vertebral centra is observed as a striking characteristic in the axial skeleton, and one which is carried still farther in *Diplacodon*. The long and narrow form of the sacrum departs widely from the characters of this bone in recent forms; and lastly, the very short caudal region is different from that of *Rhinoceros*. The characters of the appendicular skeleton are interesting, and differ considerably from those of recent Perissodactyles. The shortness and breadth of the scapula, the large size of the coracoid process, the presence of the scapular tuberosity and the want of any coraco-scapular notch are of interest as characters of this bone. The difference in shape and subdivisions of the trochleæ of the humerus in this species is very striking when compared with those of the Tapir or Rhinoceros. The form of the bones of the lower arm is found to be closely similar to those of the Tapir, although the ulna, in its relation to the carpus, is somewhat different. In the carpus is found many striking characters very different from those of the Tapir. The following are some of the most important: the mesaxial line of the manus passes nearer through the ectal side of the metacarpal III than it does in the Tapir, and there is not the same disparity in the size of the metapodials in *Palæosyops* as compared with those of the Tapir; in other words the metacarpal III approaches nearer the size of metacarpal IV than in *Tapirus*. It was also found that metacarpal V was not as much reduced as in the latter form. The penetration of the distal face of the lunar between the magnum and unciform, is a character not found in the Tapir. The more vertical lunar-magnum articulation is also a peculiarity of this carpus, this character being greatly augmented in the allied genus *Limnohyops*. The form of the unciform is very different from that of the Tapir and its large contact with the lunar is striking.

The square form of the cuneiform and the shutting out of the pisiform from the anterior aspect of the carpus distinguishes this species from *Tapirus*. In its short and wide-spreading metapodials *P. paludosus* differs widely from recent forms. In its rather short and broad pelvis it approaches the Rhinoceros, but differs very much from the Tapir in the want of a triradiate ilium, this bone in *P. paludosus* being undivided. Most of the characters of the femur are found to be closely related to those of the Tapir, but in the flatness of the lower portion of the shaft and especially of its posterior face it differs from the latter. The fact that the femur of *P. paludosus* lacks a fossa for the flexor perforatus distinguishes it also from that of the Tapir. The form of the great trochanter of the femur is found to be intermediate between that of *Tapirus* and *Equus*. The large size of the lesser trochanter is also a conspicuous feature of the femur of *P. paludosus*. In the shape of its tibial tuberosity and the want of an incision for the extensor muscle of the tibia it differs from the femur of *Tapirus*. The wide separation of the facets of the calcaneum and astragalus and the large contact between the latter and the cuboid are found to be different from the condition of the parts in the Tapir. In the tarsus also, the middle metapodial is not much larger than the laterals. The ectocuneiform articulates, moreover, with only one metapodial, viz: metatarsal II, the reverse type of tarsal articulation being wanting.

RESTORATION.

The restoration of *Palæosyops paludosus* is derived from material in the collections of the Academy of Natural Sciences of Philadelphia and of the Princeton Museum. The restoration of the skull is from the fine specimens in the Academy. The axial skeleton is restored from the material in the Princeton collection.



Palæosyops paludosus Leidy.—Restoration. About one-twelfth actual size.

This drawing is nearly all derived from material in the Princeton collection; the skull having been drawn from two specimens in the Academy of Natural Sciences of Philadelphia. The drawing was prepared under the direction of Prof. H. F. Osborn.

The hind limb is restored from the finely preserved specimen of this extremity in the Princeton Museum. It is associated with parts of an anterior limb and also a right maxillary portion of the skull containing the teeth, so there is no doubt as to its correct identification. Lastly, the parts of the anterior limb that are wanting in the specimen above referred to, are restored from the closely allied genus *Limnohyops.* I believe that this restoration is nearly accurate in all its details, as there is such an abundance of material of *Palæosyops* in the Princeton collection that nearly every part can be accurately restored. The figure[1] is drawn in perspective with the

[1] I am under obligations to Prof. Osborn for having loaned me the figure of the restoration, and also for some of the drawings for the plates.

animal placed obliquely in relation to the plane of the paper. Our study of *Palæosyops* leads to the conclusion that *P. paludosus*, in the character and form of its skull, is more closely related to the Tapir than to any other living animal, although in regard to size *Palæosyops* departs considerably from the Tapir and is intermediate between *Tapirus indicus* and *Rhinoceros bicornis*. The accompanying measurements will show the intermediate position of this animal with regard to size. The increased length and heaviness of all the bones of the skeleton demonstrate conclusively that this species was not only heavier than the Tapir, but that the total length of the animal was greater.

COMPARATIVE MEASUREMENTS.

	R. bicornis.	P. paludosus.	T. indicus.
	M.	M.	M.
Length of head and neck	·88	·74	·65
Total length of body	2·13	2·00	1·80
Height at shoulder	*1·09	*·94	*·88
Height at thigh	1·16	1·00	·87
Depth of thorax at 4–5 rib	·52	·45	·35

*Not including Vertebral Spines.

The measurements of the limbs prove that *P. paludosus* was raised higher from the ground than *Tapirus*. The length of the head and neck as compared with that of the fore limbs is slightly less (.03cm) in *P. paludosus* than in the Tapir.

The form of the skull differs considerably in this species from that of the Tapir and this applies especially to the muzzle, which was much shorter and more obtuse than the Tapir's and was not provided with a proboscis. In its short and heavy facial region *P. paludosus* resembles the Bear, and this resemblance is more strongly marked by the presence of its huge canine teeth.

The great breadth of the temporal region with its large development of zygomas is more like that of the Bears than of *Tapirus*. The position of the small eye and the general form of the cranium proper are very like those characters in the Tapir. The peculiar modification of the zygapophyses of the lumbar vertebræ points to the fact that this animal may have been more agile in its movements than the Tapir in which the vertebral processes are flat. The articular surfaces of the limb bones resemble more closely those of the Tapir, and the position of the limbs was probably the same as in that animal. The manus and pes are broader and heavier than those of the Tapir; the metapodials especially are stouter. The tail is very short. As the palæobotany of the Bridger eocene closely resembles that of the subtropical regions of the present day, we may conclude that the food of *Palæosyops paludosus* was much like that of the present Tapir, and as the remains of this animal are always found in the Tertiary Lake basins, it is probable that the habits of *P. paludosus* were like those of the Tapir, that is to say, it led a partially aquatic life.

Palæosyops vallidens.

This species has been described by Prof. Cope[1] from a lower jaw which was discovered in the Washakie Eocene. He also described a series of superior molars under the same name, but was doubtful whether they should be assigned to this species or not. I have shown elsewhere[2] that the latter specimens should be referred to *Telmatotherium validus* Marsh. I am uncertain whether *P. vallidens* should really hold a specific rank, as the characters of its molars are so closely related to those of *Telmatotherium* that it is difficult to separate it from the latter genus. At any rate it is one of the most interesting varieties or species of this subfamily that I have studied and is a true connecting form between *Palæosyops* and *Telmatotherium*, thus showing how closely these two genera are related to each other.

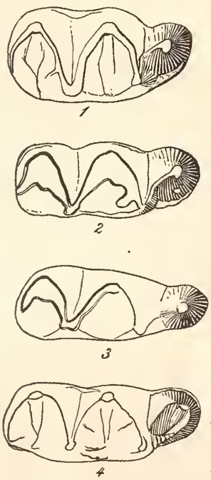


Figure 4.—A series of last inferior molars to show the form of the posterior tubercle. *1. Palæosyops paludosus. 2. Palæosyops paludosus*, variety. *3. Palæosyops vallidens. 4. Telmatotherium cultridens.* Two-thirds natural size.

The diagnostic characters of this species are the position and form of the posterior tubercle of the last lower molar, which in this variety assumes the character of this lobe in *P. paludosus*; but in other respects all the characters of the teeth are really those of *Telmatotherium*.

Dentition.—The teeth have high and elongated crowns such as we find in the genus *Telmatotherium.* Their lobes and crests are very prominent, with sharp cutting surfaces. The molars are totally without external cingula. In the premolar series there is no well-marked diastema in the jaw under consideration, which would distinguish this species from *T. hyognathus*, although the total measurements of the molar series are about equal.

The first premolar is wanting in this jaw; the second has a very high protoconid, which exhibits the same difference in size to the posterior cone that is seen in *Telmatotherium.* The V's of the last premolar are apparently not as highly developed as in the last named genus. The lobes of the two anterior true molars are very much abraided. The last inferior molar (fig. 4) is a very high crowned tooth, much elongated, with the valleys deeply bordered by prominent crests; its posterior tubercle, instead of being a functional lobe as in *Telmatotherium*, is only a cone, without a median valley or lateral crests. In this respect this molar resembles that of *P. paludosus* but differs from the latter in its posterior tubercle having a transverse diameter as great as the whole width of the tooth in front. Then again the last molar of this species shows its

[1]Pal. Bull. No. 7, p. 1, Aug. 22nd, 1872.

[2]Prelim. Obs. upon Palæosyops and allied genera. Proc. Acad. Nat. Sci. Phil., Jan., 1891.

close affinity to that of *Telmatotherium* in its high form, whereas in *P. paludosus* this tooth is generally very broad and low, although we have one jaw of *P. paludosus* in the collection in which it is quite elongated and narrow. I have considered the latter variety as a transition form between *P. paludosus* and the species under consideration.

P. vallidens is surely the direct transition form to *Telmatotherium*; so we have in the three species, viz: *P. paludosus* with its varieties, *P. vallidens* with its transition form of molar, and lastly in *T. cultridens*, the final differentiation of the posterior tubercle, which in the latter species has assumed the form of a true lobe, with a well-marked valley and crests. The open form of tubercle in *Telmatotherium* must be considered a case of reversion.

Lower Jaw.—The shape of the jaw in this species is very much like that of *Telmatotherium*; it is much elongated and very deep. The anterior portion of the horizontal ramus narrows more abruptly than does that of *P. paludosus*.

The body of the jaw is thinner than in *P. paludosus* and its posterior border is nearly straight and does not show the middle convexity and posterior concavity so characteristic of the mandible in the latter. The posterior inferior portion of the jaw is not strongly inflected as in the last named species. The angle of the jaw in this specimen is wanting. The coronoid process is high and slender—much higher than the condyle. The region of the symphysis is more procumbent than in *P. paludosus*. The dental foramen is large, placed anterior to the median line of the ascending ramus and on a line with the molars. The mental foramen is large and placed below the second premolar. From the consideration of the characters of this jaw we see that this species was more closely related to *Telmatotherium validus* than to *P. paludosus*.

PALÆOSYOPS LÆVIDENS.

(Not *P. paludosus* Leidy.)

Prof. Cope[1] has established this species upon the characters of a fine skull in his collection. He considers this species probably equal to Leidy's smaller form—our *P. minor*; but in this identification I cannot agree. I shall point out later the differences in the dental characters of these two species. In some respects the characters of the skull of *P. lævidens*, like those of the teeth, approach closely those of *L. laticeps*.

Dentition.—The dentition is interesting as it is very closely related to that of *Limnohyops laticeps*, and I consider the molar characters of *P. lævidens* much more closely related to that species than to *P. minor*.

The fact that the second superior premolar has only one external lobe is unique, and upon this character Cope has established the species. In the dimensions of its teeth *P. lævidens* approaches more closely *P. minor*. The characters of the incisors are typical of the genus, viz: rounded cones without cingular bases. Both the pre- and postcanine diastemas are very small. All the premolars except the

[1]Annual Report U. S. Geol. Surv. Terr., 1872 (1873) p. 591.

first have well-marked internal lobes (although in Cope's figure of this species the internal lobe of superior premolar 2 is omitted), and their internal basal cingula are incomplete. The last premolar is considerably smaller transversely than molar 1. In this character it differs from *P. minor* where these two teeth are more nearly of the same dimensions. The measurements of the molar series are much less than in *P. paludosus* or *L. laticeps*. The crowns of the molars are low, without external cingula; the buttresses are well developed, the anterior is prolonged, the median buttress being of the typical Palæosyops form; that is to say, not widely constricted off.

In its molar characters *P. lævidens* differs very much from *P. minor*, in which the crowns of the molars are high, with prominent external cingula. The intermediate conules are reduced. As Cope[1] says "The anterior median small tubercle of the first true molar is wanting". This is a character very different from that of *P. paludosus* where the protoconules of the superior molars are always very large. The internal cones of the molars are low, and in the last superior molar the posterior internal angle has quite a large basal enlargement. This portion of the tooth is damaged, but I think it points to the fact that we are here dealing with another species in which a rudimentary hypocone is present on the last upper molar.

Prof. Cope[2] figures another series of molars which he supposes to belong to this species. Their dimensions are intermediate between those of *P. lævidens* and *P. paludosus*. These teeth are no smaller than some molars which we have referred to *P. paludosus* in the Princeton collection, so I think they should be referred to that species. The last premolar of the above mentioned series has its external lobes without a trace of a median buttress. This is a character which is variable in *P. paludosus*, but is generally present. The intermediate conules in the above mentioned molars are well developed, and the last premolar is smaller than the first true molar transversely. In both series of molars described by Cope as belonging to this species the enamel is smooth.

Skull (Fig. 2, p. 289).—The facial region of the skull of this species in Prof. Cope's collection is very finely preserved; it is rather short and, when compared with this region in the skull of *P. paludosus*, is much higher and more compressed. This is especially noticeable in the height of the roof of the skull above the premolars. The nasals are much elongated, narrow and not expanded distally.

The characters of the nasals are nearly the same of those of *L. laticeps*. The nasal notch is deep; its superior border slopes gradually downward, but the inferior, instead of being nearly parallel with the superior, diverges widely from it and thus makes the anterior narial opening very large. The premaxillaries are much elongated from above downward, and short antero-posteriorly. Their symphysis is filled up by a matrix in this skull, although Prof. Cope considers that there was no union between these bones. This would be an exception to the rule

[1]Tertiary Vertebrata, page 703.

[2]Tertiary Vertebrata, Pl. L, fig. 3.

in this subfamily of having no median junction of the premaxillaries while in all other species these bones have a broad symphysial attachment.

The anterior border of the orbit is placed over the posterior third of the first molar. The floor of the orbit is rather elongated and the orbital process of the frontal is large. The zygomatic arch is very heavy, and its squamosal division presents a broad external face. The arch is strongly descending, and the zygomatic portion has a very long horizontal connection with the malar. The malar arises abruptly from the cheek, presenting outwardly a sharp external ridge, and inferiorly a broad horizontal surface. The malar insertion resembles very closely that of *L. laticeps*. The infraorbital foramen is large and not exposed. Most of the cranial portion of this skull is wanting, but enough remains of the auditory region to show that the postglenoid was short and heavy, being more like the form of this process in *P. megarhinus*.

PALÆOSYOPS BOREALIS.

This species has been described by Prof. Cope[1] from a portion of a right maxillary bone containing the last three true molars and also one premolar. Other portions of the skeleton have also been described by him in his "Tertiary Vertebrata". As this is the earliest species of the genus in its geological horizon and as it is associated with such forms as *Lambdotherium popoagicum*, both from the Wind River Eocene of Wyoming, we should expect to find some interesting primitive characters more closely connecting it with *Lambdotherium* than with the higher species of *Palæosyops*. In my opinion, however, such is not the case, and I find in the molars of *P. borealis* advanced dental characters which relate it much more closely to *Palæosyops* than to *Lambdotherium*. Perhaps this may indicate that *Lambdotherium* is not the direct ancestor of the Palæosyops line, and that we must look to an earlier geological period for the common ancestor of both *Lambdotherium* and *Palæosyops*.

Dentition.—The last superior premolar, the only one of this series preserved, is smaller transversely than the first true molar. Its external face is straight and shows no median buttress. Its anterior lobe is provided with a slightly marked vertical fold. The paracone is larger than the metacone. Its internal lobe is large, low and blunt, and the tooth is provided with a well developed protoconule. In *Lambdotherium* a large protoconule is present upon the last superior premolar, and this conule is much larger than that of *P. borealis*. The absence of this conule from the premolar series of the higher genera of this subfamily is to be remarked; so that this character in *P. borealis* must be considered a primitive one. The last superior premolar of *P. borealis* is provided with an incomplete basal cingulum, and its anterior and posterior cingula are very conspicuous.

In the true molars we have much more highly differentiated teeth than in *Lambdotherium*, the external V's being more strongly expressed than in that genus. The external lobes of the molars have not those conspicuous vertical folds between

[1]American Naturalist, 1880, page 746.

the buttresses which are so characteristic of the external V's in *Lambdotherium.* The form of the molar in *P. borealis* approaches more closely that of *Telmatotherium* than of *Palæosyops*, being of a nearly square form without very prominent external buttresses. The external lobes of the molars are moderately high, and traces of an external cingulum are present. The protoconule of all the three superior molars is large, especially that of molars 2 and 3. There is no metaconule upon molar 1. The second and third molars in this specimen are so badly damaged that it is impossible to determine the presence of this conule.

Slight traces of transverse ridges are to be seen in the molars of *P. borealis.* In the first molar these ridges are only slightly developed, whereas in the last molar the anterior ridge connecting the paracone with the protoconule is plainly to be seen. The last named conule is largely developed. Compared with those of *Lambdotherium* the protoconules and transverse ridges of *P. borealis* are not nearly so strongly developed. The smaller size and the peculiar oblique form of the external face of the true molars in *Lambdotherium* will also readily distinguish the teeth of that genus from *P. borealis.*

The Skeleton.—The parts of the skeleton associated with the dentition of this species are very interesting, and the characters of the well preserved lunar strongly remind one of those of *Limnohyops.* This lunar is high and narrow, like that of *L. laticeps ;* its distal part is prolonged, with the lunar-magnum facet nearly vertical in position. The lunar-unciform facet is large and deeply concave. The characters of the lunar are also closely related to those of *Lambdotherium.* A well preserved distal portion of a radius (= .031 m.) shows this species to have been very much smaller than any other of the known members of the genus.

PALÆOSYOPS MEGARHINUS.

I have established this species[1] upon the characters of a fine skull (No. 10,-008) in the Princeton collection. Unfortunately most of the teeth in this specimen are very badly damaged, only portions of one canine and of the last molar being intact.

Dentition.—The fangs of the incisors which are preserved show that these teeth are much smaller than those of *P. paludosus*, and there is only a small diastema between the outer incisor and the canine. The canines of *P. megarhinus* are peculiar in form ; they are very small, round in section and diverge widely from the skull. The canine aveolus is very prominent and is a strong character in the skull of this species. Only the roots of the premolar series are preserved in the specimen. They were probably all much smaller than the premolars of *P. paludosus.* There is a considerable difference in the transverse extent of the last premolar and that of molar 1. The last upper molar is partially preserved and shows clearly traces of only one internal cone, a character which places with certainty the generic position of this species. This tooth has a low crown and rather broad and

[1]American Naturalist, Jan. 1891, page 45.

shallow external V's which are totally without an external cingulum. The median buttress of this molar was probably well constricted off. The intermediate conules of the last superior molar are small and reduced. The measurements of the dental series agree with those of *P. lævidens*, although in the latter species a small diastema is present, which is totally wanting in the dentition of *P. megarhinus*, this being a unique character of this species.

The Skull (Pl. X, fig. 2).—I have referred two skulls in the collection of Princeton College to this species. The first, No. 10,008, is almost perfectly preserved as far back as the glenoid region. The other is an occipital portion, No. 10,041, with the auditory processes and basal region finely preserved. The proportions of the facial and cranial regions of the skull of this species and their general contour, are very different from those of *P. paludosus*. The dorsal contour is without any prominent frontal depression, this part of the skull forming a gradually rising surface as far as the middle temporal region, the latter portion being slightly higher than the occipital. The facial region is very short and strongly compressed at the middle portion, with heavy and overhanging nasals. The cranial and facial axes form a slight angle with one another. The zygomatic fossa is extremely elongated, and the anterior boundary of the orbit is more widely prolonged forward than in *P. paludosus*. The orbit is extremely small and Bear-like in this species; it is nearly shut off from the temporal fossa by a strongly developed post-orbital process. The occipital region is proportionately higher and narrower than in the larger forms of the genus. The occipital crests are strongly compressed, thin and high. The sagittal crest is much more strongly developed than in *P. paludosus*. It is very thin, high and extends farther forward before diverging into the temporal ridges than in the latter species. The anterior temporal ridges are weakly developed, and the interorbital region narrower and more compressed than in *P. paludosus*.

The narrow and nearly straight zygomatic arch is very different in form from that of the allied species of this genus. The shape of the auditory processes is another character which distinguishes this species from all others of the genus, with the possible exception of *P. lævidens*. The basal region of the skull is narrower than in the larger species. The posterior narial opening is narrow and has its walls strongly compressed. The palate is rather long and narrow, with the roof arched; its posterior margin is rounded with a median prolongation. The posterior limit of the palate is at the second molar.

Nasals and Premaxillaries (Pl. XI, fig. 4.)—The premaxillaries differ in form from those of *P. paludosus*, they are short with a small linear-shaped median symphysis. The anterior aspect of the symphysis presents a prominent median keel. Upon each side of the latter the surface of the bone is concave, and is bounded posteriorly by the prominent canine alveolus. Viewed from below the premaxillaries have a decided triangular outline, with a short and oblique contour for the incisors. The palatal extension of the premaxillaries is more limited in this species than in *P. paludosus*; and the large and apparently single incisive foramen is situated on a line anterior to the canines. The form of the nasals is very characteristic of *P. megarhinus*, distinguishing it from any other species of this group. They are much elongated and convex at the middle portion, becoming wider and strongly depressed at the extremities which are expanded and broader than the middle portion. This character of the nasals distinguishes them from those of the other species of the subfamily. The posterior portions of these bones are broad and they articulate laterally with the maxillaries by broad plates. Their posterior extension is on a line with the anterior part of the orbits. The nasal notches are rather short, but higher than in *P. paludosus*; their superior and inferior outlines are more sinuous than in the latter species; the part of the nasal notch formed by the maxillary is concave anteriorly and then rises gradually to the superior termination. The maxillaries take a rather larger share in the formation of the nasal notches than the premaxillaries, whose superior limit is above the posterior border of the first premolar.

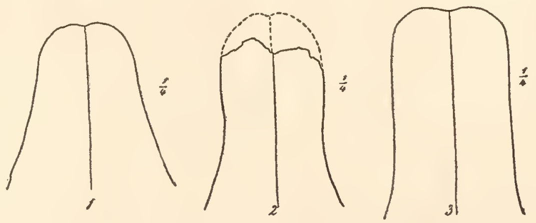


FIGURE 5.—Outline of Nasals. *1. Palæosyops paludosus. 2. Palæosyops megarhinus. 3. Limnohyops laticeps.* One-quarter natural size.

Proboscis.—There is a wide difference of opinion among palæontologists as to the presence or absence of a proboscis in certain groups of fossil animals. As it is important to decide whether or not an animal bore a proboscis, I shall treat the question as thoroughly as possible and give my own conclusions upon the subject. They are derived from the study of a number of different groups of animals which are said to be proboscis-bearing. Prof. Cope[1] in summing up the affinities of the Dinocerata as compared with those of the Proboscidea says "the possession of a proboscis is proven by the extreme shortness and stoutness of the free portion of the nasal bones, by the very short cervical vertebræ, and by the fact that the nasals and premaxillary bones are deeply excavated at their extremities, with surrounding osseous eminences for the origin of the muscles of the trunk."

On the other hand, Prof. Marsh,[2] in his restoration of *Dinoceras* says: "the neck was long enough to permit the head to reach the ground, and hence a proboscis was quite unnecessary. The horizontal narial opening, the long overhang-

[1]Tertiary Vertebrata, page 511.

[2]Monograph of the Dinocerata, page 166.

ing nasal bones and the well developed turbinal bones are likewise positive proof against the presence of such an organ.. There is some evidence of a thick flexible lip, resembling perhaps that of the existing Rhinoceros."

We see from the above quotations that these authors hold diametrically opposite views regarding the occurrence of a proboscis in the Dinocerata. My own studies upon the subject lead me to coincide with Prof. Marsh's views, and I consider that the Dinocerata were unprovided with a true proboscis. In order to form an opinion as to the absence or presence of a proboscis in the Ungulates I submit the following statement. The European Palæotheroids form one of the most interesting series in this connection and Prof. Gaudry[1] has expressed the opinion that in *P. crassum* a proboscis was wanting. He observes that in the last named species the nasal bones are large and project farther anteriorly than in *P. medium*, and consequently the proboscis was more reduced. It appears to me that this character should guide us in deciding whether or not a fossil Ungulate bore a proboscis. As already noticed in *Palæotherium crassum*, the nasals do not reach as far forward as the premaxillary suture, and the nasal notches are well developed. On the other hand in *P. medium* the nasals are much more reduced, their anterior extremities reaching to about the middle of the nasal notches. In *P. magnum* the abbreviation of the nasals is carried still farther, and in the recent Tapir we see their greatest reduetion. Coincident with this shortening of the nasal bones in the Tapir is the development of a large proboscis. In the Elephant, the most specialized animal as regards a proboscis, we have the process carried to its farthest point, the the nasal bones being very small and placed in nearly the middle of the skull. In this animal the proboscis is enlarged into a trunk. Accordingly the presence of a proboscis seems to depend on the reduction or shortening of the nasals, and their being placed farther back than usual on the skull. With this recession of the nasals from the premaxillary region there is, of course, more mobility given to this part of the face, and consequently, where the nasal tips are placed far behind as in the Tapir, a large proboscis is developed, this organ being movable in all directions. If the nasal tips extended as far forward as the premaxillary suture this free play of the proboscis would be impossible. The mere shortening of the cervical region is not the cause. or at least not always the cause of an extension of the nasal region into a proboscis. In the Rhinoceros, for example, which is a more bulky animal, having the neck shorter than the Tapir, there is no proboscis developed, whereas in the more slightly constructed Tapir a well developed proboscis is present. In a group separated widely from the Ungulates, viz: the *Insectivora*, there are two genera, *Macroselides* and *Myogale*, which have a well developed proboscis. I have not had an opportunity to examine the structure of the skull in these genera, but owing to their small size I should think it would not be specially modified as in the Perissodactyles. In the genus *Cystophora* (*Pinnepidia*) the nasals are

[1]Les Enchainments du Monde Animal, etc., page 46.

very much reduced and limited posteriorly, and the animal has a large proboscis. On referring to the Dinocerata, it is found that these animals have the nasal region constructed in about the same way as in the recent Rhinoceros, with the difference that the nasals are prolonged beyond the premaxillary suture in *Dinoceras.* I believe that they were without a proboscis, but probably had a very large and prehensile lip. I am led to this conclusion by the great posterior and vertical extent of the lateral nasal notches. Accepting the above data as probably establishing the presence of a proboscis, I conclude that *Palæosyops megarhinus* was without such an organ, because in this species, as in all others of this subfamily as far as known, the nasal bones are very largely developed and extend so far forward as to overhang the premaxillary region. The lateral nasal notches of *P. megarhinus* are deep, but not high, and probably for this reason the upper lip was not as prehensile as in the Rhinoceros. In *Titanotherium* the nasal notches are larger and there was probably more freedom of motion in this region.

Frontals.—The frontals are rather broad and short. They widen very much anteriorly, and have only a slight articulation with the ascending processes of the maxillary. The articulation between the frontals and nasals is broad and extends across the whole forehead. The interorbital region of the frontals is rather broad, convex, and sends out long and acuminate lateral postorbital processes. The portion of the frontals forming the superciliary border of the orbit is thick and rounded off. The posterior part of the frontals forming the anterior portion of the temporal fossa is not strongly excavated and is bordered above by weakly developed anterior temporal ridges.

Parietals.—The parietals unite along their whole superior extent to form the sagittal crest. The latter is high, strongly compressed, and arises from the upper third of the temporal fossa, thus forming the extremely high roof of the cranial cavity. At the junction of the parietals and squamosals the surface of the temporal fossa is strongly convex and shows a well marked bulging of the cranial cavity outward. In the skull of *P. paludosus* the whole surface of the temporal fossa is deeply excavated, showing a less development of the lateral masses of the cerebrum than in *P. megarhinus.*

Occipitals.—The condyloid portion of the exoccipitals is strongly constricted off from the supraoccipital region, thus placing the foramen magnum widely back from the surface of the occiput. The portion above the foramen magnum is smooth and superiorly overhung by the well developed lambdoidal crest. These crests are well developed as far as the lateral parts of the occiput, and are proportionately larger in this region of *P. megarhinus* than in *P. paludosus.* The paroccipital processes have much less transverse extent in this species than in the larger form, and their extremities are more styliform. The condyles are broad and heavy, and their transverse extent is as great as in *P. paludosus.* Superiorly the condyles are separated by a wide and straight notch; their inferior extremities are prolonged upon the basioccipital and separated by a slight interval. The basioccipital is shorter and narrower than in *P. paludosus* and its anterior keel-like and lateral muscular rugosities are very prominent. The lateral vacuities of the skull are more elongated and narrower than in the larger species, and are encroached upon laterally by the periotic bones. The lamina of bone between the lateral vacuities and the foramen ovale is perfectly flat and broad in this specimen.

Sphenoidal and Pterygoid Region (Pl. XI, fig. 5).—Just in front of the foramen ovale the roots of the pterygoid processes of the sphenoid arise, and they extend anteriorly to form the walls of the narrow posterior narial opening. The posterior nares in this species is much more contracted than in the Tapir. The wings of the sphenoid forming its inferior termination are not nearly so widely expanded as in the Tapir's skull, and the whole extent of the nares from the posterior limit of the palate to its termination at the hamular processes, form, as it were, a narrow trough, the anterior and narrow walls being bent inward and thus contracting the narial space. The sphenoid sends wide horizontal plates posteriorly, and the alisphenoid extends about half way up the side of the temporal fossa. It articulates with the frontals and was probably shut off from articulation with the parietals as in the Tapir's skull. The damaged condition of the specimen does not allow us to define the orbitosphenoidal region. The presphenoid is narrower and more elongated than in *P. paludosus*; it shows upon its ventral surface a prominent keel, and upon each side of the same are the prominent and vertical walls of the alisphenoid canal.

Squamosal.—The squamosal forms about the lower half of the temporal fossa. Its external surface is not as deeply excavated as in the larger species of the genus; its posterior portion presents a number of small foramina. The zygomatic process of this species is very characteristic and quite different in form from that of *P. paludosus.* Instead of being broad, flat and widely extended from the temporal fossa the zygoma of *P. megarhinus* is narrow, depressed and presents only a narrow external face. The zygoma in this species is not set off so far from the surface of the skull as in others of the genus, as its extreme posterior portion where it joins the squamosal is narrow. The course of the zygomatic arch is more descending than in *P. paludosus,* and at its middle part it is thin and narrow, being in this respect in strong contrast to the arch of the larger species of the genus. The auditory processes are peculiar in form; the postglenoid is very short, thick and rugose; the post-tympanics are also short and their surface is rough. The postglenoid is widely separated from the post-tympanics, so it is probable that the mastoid appeared upon the surface of the skull. In the skull under consideration there is a triangular tract between the exoccipitals and post-tympanics which was probably filled up by the mastoid portion of the periotic. The large venous foramen situated between the paroccipital and post-tympanic, which is so characteristic of the larger species, appears to be wanting in this skull. The glenoid facet is long and narrow, and the anterior surface of the postglenoid is smooth for articulation with the jaw. An internal glenoid process is present in this species.

Malar.—The form of the malar is peculiar and highly characteristic. Instead of the malar insertion being gradual and compressed, its insertion at the cheek is very abrupt and rounded anteriorly. Viewed from the side, the portion of the malar forming the suborbital border is strongly depressed, and forms as it were a broad and thin shelf-like projection, which at its external margins becomes thin and bent downward with its superior and inferior surfaces concave. The postorbital portion of the malar is thin and bent inward. This portion of the zygomatic arch is weakly developed as compared with that of *P. paludosus.* The malar postorbital process is large and sharp.

Maxillary.—The ascending plate of the maxillary is vertical and its surface is plane; its antero-posterior diameter is not greater than its vertical, owing to the very short facial region of this species. The portion of the maxillary forming the floor of the orbit is broad and deep, much more so than in *P. paludosus.* The antero-posterior extent of the orbital floor is much greater than in the larger species, and in this character *P. megarhinus* agrees with *Telmatotherium.* The prominent canine aveolus forms an abrupt termination to the maxillary region anteriorly. The infraorbital foramen is large and situated above the first true molar. The large lamina between the nasal notch and the orbit is formed mainly by the naso-maxillary articulation. A small opening at the antero-superior part of the orbit is evidently for the lachrymal duct. Its opening is small, and the lachrymal bone probably only formed a small part of the cheek as in the skull of the Tapir.

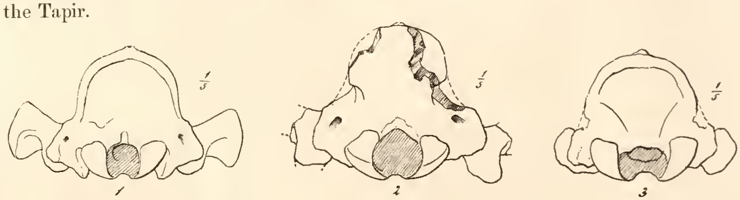


FIGURE 6.—Comparative views of the occipital region. *1. Limnohyops laticeps. 2. Palæosyops paludosus. 3. Palæosyops megarhinus.* One-fifth natural size.

Foramina.—The condyloid foramen is large in *P. megarhinus* and is situated nearer the foramen magnum than in *P. paludosus.* The foramen laccrum posterius and medium are fused with the large lateral vacuity. The foramen ovale is large and situated about an inch in front of the foramen lacerum medium. The posterior opening of the alisphenoid canal is about seven-eigths of an inch below the foramen ovale. The antero-posterior extent of this canal is nearly twice as great as in the Tapir. The portion of the sphenoid forming the outer walls of the alisphenoid canal is strongly convex and very prominent.

Cranial cavity.—The general form of the cerebral cavity in this species is an elongated oval, with a very much reduced vertical diameter. This is strikingly apparent when we compare the cranial cavity of a Tapir with that of *Palæosyops* *megarhinus.* In the latter the vertical height of the cerebral fossa is no greater than that of the cerebellar fossa, whereas in recent Perissodactyles, where the cerebral lobes are very large and have a great vertical extent, the cerebral fossa ranges high above the cavity for the cerebellum. The anterior limit of the cranial cavity in *P. megarhinus* is on a vertical line with the middle of the alisphenoid canal.

In the Tapir this cavity is prolonged farther forward and reaches about the middle of the wings of the sphenoid. Owing to the low reptilian-like form of brain that occurs in this species the arrangement of the subdivisions of the cranial cavity follow one another in regular order, and there is not that superior position of the olfactory fossæ that is seen in recent forms. In other words the floor of the cerebral cavity is nearly straight, and this is especially noticeable in the region anterior to the pituitary fossa, which is not so oblique and ascending as in the Tapir's skull. Another primitive character of the cranial cavity of this species is that the cerebellar fossa is strongly marked off from the cerebral by a well developed ossified tentorium which extends all around the walls and roof of the cranial cavity, and is as strongly marked in the skull of *P. megarhinus* as it is in that of the Carnivora. In the skull of the Bear, for example, the large size of the tentorium is noticeable. In recent Perissodactyles the presence of an ossified septum between the two posterior subdivisions of the cranial cavity is reduced to a minimum; in the Tapir it is totally wanting; in some species of *Rhinoceros* it is also absent, whereas in other species of this genus a single elongated curtain-like process may be developed upon the roof of the cranial cavity. This is also the case in *Equus*. The olfactory fossæ are elongated and well separated from the cerebral cavity. The elongation of these fossæ is a noticeable character of this species. The olfactory fossa of each side is separated from that of the other by a stout septum, which rises from the anterior floor of the cerebral cavity. In recent forms the olfactory cavities are carried upward and are oblique in position, but their primitive position is found in *Palæosyops*. In correlation with the great lateral reduction of the brain of this species is the encroachment of the brain-case upon the encephalic mass. The walls of the brain-case are extremely thick and heavy; this is especially noticeable in the roof of the skull, which is over twice as thick vertically as in the Tapir's skull. The reduction of the brain is especially appreciated when the extremely deep temporal fossæ are seen from without.

Brain, (Pl. II, figs. 6, 7.)—This is the only species of the subfamily whose brain we are able to figure. There are a number of brain-casts in the collection, all being from the same skull, No. 10,041. The brain of *Palæosoyps megarhinus*, like most of the Eocene Ungulates, is very small, and when we compare the size of the brain in the Tapir with that of this species we are at once struck by the great discrepancy in their size. In the form and arrangement of its lobes the brain of *P. megarhinus* is intermediate between those of *Phenacodus* and *Tapirus*. Compared with the size of the skull the brain of *P. megarhinus* was larger than that of *Titanotherium*. In the latter genus the breadth of the encephalon is unusually developed as compared with its length. The axes of the fore and hind brain are continuous, and are not bent upon each other as in the Tapir's brain, and that of the higher Ungulates.

Cerebrum.—The prosencephalic lobes are very broad, short and somewhat depressed; their general outline is a broad oval with only a slight distinction between the frontal and occipital portion. Viewed from the side the temporal lobe is much less marked than in the Tapir's brain. The inferior surface of the frontal portion of the cerebrum is convex and not concave as in the Tapir. The surface of the hemispheres is well convoluted; and in this respect this species shows a marked advance over such early Eocene forms as *Phenacodus* and *Coryphodon*. The Sylvian sulcus is well developed and vertical in position. There are also well marked pre- and post-sylvian sulci, in continuity with the main sulcus. The surface of the brain between the Sylvian sulcus and the hippocampal is smooth and strongly convex; as there is no fissure between the two last mentioned sulci we may conclude that the Rhinal and Sylvian sulci have coalesced as in the Carnivora. In the Tapir and Rhinoceros the Sylvian and Rhinal sulci are distinct, and the presylvian is separated from the Sylvian proper, although its primitive condition is in connection with the latter. A long wavy fissure above the superior termination of the Sylvian sulcus is evidently the suprasylvian fissure. It extends from the posterior part of the occipital lobe well forward to the middle portion of the frontal; in its course it throws off a number of secondary sulci. There is an indication that the crucial sulcus was present in this brain, but the coronal, so characteristic of the brains of recent Ungulates, is absent. The lateral portion of the occipital lobe above the posterior prolongation of the Sylvian sulcus is provided with an oblique fissure, which is probably the one called by Krueg the posterior fissure. The convolutions of the brain in *P. megarhinus* compared with those of the Tapir are less numerous and complex. In the Tapir's brain the longitudinal secondary fissures are more numerous, and the frontal lobes of the hemispheres are much larger than in *P. megarhinus*. This region is also more convolute in the Tapir. The olfactory lobes in the brain of *P. megarhinus* are large and strongly prolonged anteriorly. They differ in form from those of recent Perissodactyles, where they are more vertically placed, their long axes being from above downward and closely connected along their whole extent with the surface of the hemispheres. The olfactory lobes in *P. megarhinus* were separated, and probably much longer than represented in the drawing, as in the cast they appear to be abruptly cut off.

Midbrain.—In *Phenacodus primævus* the prosencephalic lobes are widely separated from the cerebellum, leaving the midbrain region exposed as in reptiles. In *Palæosyops megarhinus* the brain is more highly developed than in *Phenacodus primævus*. Although the cerebral lobes do not reach the hind brain, they were prolonged probably far enough behind to cover the corpora quadrigemina.

Cerebellum.—The hind brain is unusually large and broad in this species. The cerebellum is as wide transversely as the whole extent of the prosencephalic lobes; it is subdivided into three narrow lobes, the median being the largest and most conspicuous. The vermis shows signs of transverse folds, but the condition of the cast does not allow this point to be made out definitely. Two small appendages, which may be the flocculi, are given off from the cerebellum, one on each side at the antero-inferior angle of the same.

Medulla.—The medulla oblongata is peculiar in its great breadth, it being nearly as broad as the cerebellum and strongly depressed. The form of the medulla differs very much from this portion of the Tapir's brain, where it is round in section and much narrower than the cerebellum. The brain viewed from the side shows no contact between the the cerebrum and cerebellum. The inferior surface of the brain shows the roots of the optic nerves, and posteriorly upon each side is seen the origin of the fifth pair of nerves; a deep fossa between the two latter, bounded anteriorly by the optic nerves, is evidently the pituitary fossa. The surface of the brain posteriorly to the origin of the fifth pair is higher than the region of the pons Varolii, which, together with the inferior surface of the medulla, is very flat and wide. Just posterior to the cerebellum and upon the lateral side of the medulla, are two prominences which are probably the origin of the twelfth pair of cranial nerves.

Comparison of the Brain of Palæosyops with that of other Ungulates.

Comparing the brain of *P. megarhinus* with the lower Eocene *Amblyopoda* and *Condylarthra* we see a marked increase in its size and in the dimensions of the anterior lobes, the posterior prolongation of the latter approaching the region of hind brain, thus differing very much from the Wasatch forms. Although occurring in the same beds with *Palæosyops* we have the abnormally small brain of *Uintatherium*, which is unusual in the diminutive size of its encephalon. In *Hyrachyus eximius*, an animal about the "size of a large sheep[1]," we have a form with a much larger brain relatively than that of *Palæosyops*. In *Hyrachyus* the forebrain is large, with large temporal lobes. There is in the latter genus a marked difference in the breadth of the cerebrum as compared with that of the cerebellum, but if the casts of *H. eximius* can be relied upon, the convolutions of its brain were not nearly so complicated as in *Palæosyops*, the gyri running nearly longitudinally and parallel. The general form of the prosencephalon in *Hyrachyus* closely resembles that of the recent Carnivora. The whole bulk of the brain of *P. megarhinus* compared with that of the Tapir, is nearly one-half less, whereas in the brain of *Hyrachyus* compared with that of *Ovis*, this difference is not nearly so great. Marsh's figures of the brain of *Titanotherium* indicate that the forebrain did not extend at all over the hind brain, although the hemispheres were "richly convoluted," their width and the large development of the temporal region being greater than in *Palæosyops*. In the convoluted surface of its hemispheres *P. megarhinus* approaches the Tapir and is much more highly developed in this respect than any of the Eocene forms which I have studied. The great size and breadth of

[1]Tertiary Vertebrata, page 672.

the hind brain in *Palæosyops* distinguish this genus from recent Ungulates, approaching more nearly the conditions seen in the *Condylarthra* (*Phenacodus*).

Brain Measurements. (*Volume*).

Tapirus indicus	320 cc.
Palæosyops megarhinus	180 "
Hyrachyus eximius	096 "
Ovis aries	095 "

Summary of Brain Characters.—The following are the peculiarities of the brain of *P. megarhinus*:—1. Reduced size of forebrain, especially the frontal lobes. 2. Separation of fore-brain from hind-brain. 3. Large size of cerebellum. 4. Great breadth of the medulla oblongata.

Brain Measurements of P. megarhinus.

	M.
Total length of brain	·100
Length of hemispheres	·070
Breadth of hemispheres	·065
Height of hemispheres at temporal lobe	·044
Length of occipital lobes of hemispheres	·034
Length of frontal " " "	·020
Breadth of olfactory lobes	·038
Breadth of mid-brain	·037
Breadth of cerebellum	·055
Antero-posterior extent of vermis	·036
Vertical height of cerebellum	·047
Width of medulla	·046

Palæosyops minor.

The relation of this smaller species of the genus *Palæosyops* to *P. paludosus* has been shown in our preliminary paper.[1] I will merely add that *P. minor* embraces specimens which Dr. Leidy erroneously assigned to *P. paludosus*. They are illustrated by figures 3–6, Plate IV, of his report for 1873.[2] They comprise a complete series of superior molars. Other specimens of this species figured by Leidy are a portion of the facial region containing the first three premolars, and a finely preserved lower jaw which he represents on Plate V, figure 11. In the Princeton collection the material referable to this species is very limited. There is a partial set of molars, No. 10,242, and also three portions of jaws with the teeth rather damaged, specimens No. 10,042 a, b, c. I have already mentioned the fact that the generic reference of this species is uncertain. We know nothing of the anterior premaxillary region of the skull, which is so important in distinguishing some of the genera of this subfamily. The characters of the teeth are very interesting, and show on the whole a more decided affinity to *Telmatotherium* than to *Palæosyops* although

[1]Prelim. Obs. etc., Proc. Acad. Nat. Sci. Phila., Jan. 1891, page 112.

[2]The type specimens of this species are in the Academy of Natural Sciences of Philadelphia.

in some respects they retain certain very primitive characters which prove the intermediate position of this species.

Dentition.—The incisors are not round in section as in *P. paludosus* but strongly compressed, with a rudimentary internal basal ridge. In the second incisor there is a lateral heel. The characters of the incisors are intermediate between those of *P. paludosus* and *Telmatotherium*. In Prof. Leidy's report[1] he describes two series of superior molars associated with their canines. He notices the difference in the size of the canines in the two series, as well as the character of the premolars in both specimens, and he concludes that the great difference displayed in the size of the canines is probably a sexual character. He also remarks that with the great development of the canines there is a concomitant reduction, as it were, of the premolars. I have already observed the sexual differences in the size of the canines and premolars of *P. paludosus* and quite agree with Dr. Leidy in his interpretation of these facts, although in our examples of *P. paludosus* there is not a reduction in the complexity of the premolars with the increased size of the canine. This is certainly not the case, as in the female of *P. paludosus* with smaller canines, the premolars are considerably smaller than in the male with its huge tusk-like canines. It is interesting to note that the superior premolar series of *P. minor* more closely resembles that of *Telmatotherium* and departs considerably from the characters of these teeth in *P. paludosus*. The first premolar has an elongated crown; it is the exact counterpart in form of this tooth in *T. cultridens*; its paracone is curved backwards and compressed. There is only a very slight indication of an internal cingulum to premolar 1, but the base has a slightly enlarged heel. The first premolar is separated by a slight interval from the canine and the tooth succeeding it. Premolar 2 has its anterior border very oblique with its internal cone not strongly marked. Its external lobes are subequal, the paracone being considerably higher than the metacone. The anterior V of this premolar and those of all the succeeding ones are provided with a prominent median rib. Premolars 3 and 4 have rather high crowns with equal external lobes. The latter are not separated by a median buttress. These teeth have traces of a protoconule, although the latter lobule is in a very rudimentary condition. The internal basal cingulum of all the premolars is incomplete and the external cingulum of the third and fourth is well marked. There is a difference in the transverse diameter of premolar 4 and molar 1 in this species. The explanation offered by Prof. Leidy of the difference between the two series of premolars figured by him is a very important one, and if his statement be correct that in *P. minor* there is an increase in the complexity of the anterior premolars with a decrease in the size of the canines, it obviates the necessity of making a new species out of a specimen, which, in its true molar characters, agrees almost exactly with the typical example of this species.

[1]Extinct Vertebrata, etc., page 36, 1873.

Superior molars, (Pl. XII, figs. 14, 15.)—The true molars are of the Telmatotheroid type, that is with high crowns, axes nearly equal and very prominent and wide external lobes. The median buttresses of the molars, as in *Telmatotherium*, are strongly constricted off, and the external face of the teeth are provided with a strongly marked cingulum. The portions of the V's between the buttresses are flat and even, and there is only a slight trace of the median rib. The internal cones of the molars are characterized by being very pyramidal in form, thus differing from *Telmatotherium* where these cones are sharp and round. The protocone of the last molar is large and placed opposite the concavity of the V's. The intermediate conules of the molars are only slightly developed. They all have a very small protoconule, and there is a rudiment of the metaconule on the last molar. The intermediate conules are in a state of reduction in this species and in that respect are like those of *T. cultridens* in which they are nearly wanting. The posterior internal angle of the last molar is cut off obliquely, and has not the square form which is so characteristic of *Telmatotherium*.

Inferior molars.—The beautifully preserved mandible figured by Leidy,[1] with the lower dentition nearly complete, we may consider as the type specimen. It illustrates the characters of the lower molars in this species. This jaw was not found associated with any superior molars, although we find the type specimens of the upper molars correspond very well with it. The original inferior molars which were described by Leidy,[2] I have shown in my preliminary paper to belong to *P. paludosus*. As we have already seen, the characters of the upper molars more closely resemble those of *Telmatotherium* than those of *Palæosyops*. On the other hand, the lower molars are more of the Palæosyops type; that is to say, their crowns are low and broad, the arms of the V's are not high, sharp, and bordered by deep valleys as in *Telmatotherium*. Only the last two premolars are preserved in the jaw belonging to the Academy; in premolar 3 the protoconid is much larger than the metaconid, but there is no trace of the posterior arm of the anterior V present in *P. paludosus*. The double V's of the last premolar are, however, more strongly expressed in this jaw than in that of the larger species. The entoconid of this tooth, as in that of *P. paludosus*, is wanting. The last inferior molar differs from that of *P. paludosus* in being somewhat longer in proportion to its breadth. The posterior tubercle of this tooth agrees with that of *Telmatotherium* in being a well developed lobe, although its transverse extent is much less than the transverse diameter of its molar. Both the internal and external basal cingula are wanting in these teeth. The few specimens of this species in the Princeton collection show little variation in the characters of the true molars, and as we have seen, such variation is confined mainly to the premolar series. I may add that in all the teeth examined of *P. minor* the enamel is perfectly smooth and generally of a very dark color.

[1]Report U. S. Geol. Surv. of Terr., 1873, plate V, figures 10–11.

[2]Proc. Acad. Phil., 1870, page 113.

Milk dentition, (Pl. XII, fig. 16.)—There are two small teeth from the same individual, which I consider as probably belonging to the milk dentition. I have referred them to this species provisionally because they closely approach in form and general characters the molars of *P. minor*. The first tooth closely approximates in form to the superior premolar 2 of *Telmatotherium*. Its antero-posterior axis is much drawn out, the external lobes are very sharp and high, the internal face is provided with a prominent basal ridge, from which spring two rudimentary cones, the posterior being more plainly marked than the anterior. The anterior border of this molar is very obliquely cut off, and strongly reminds one of the form of the second superior premolar of *Telmatotherium*. The second tooth in this series is considerably larger than the first, but its general form is the same. The external V's are more strongly expressed, the median buttress, being of the Telmatotheroid type, is well constricted off. Both the external V's of this molar are provided with well marked median ribs. The internal cones of the second molar are well developed and of the same size; the protocone is nearly separated from the internal cingulum, whereas the hypocone is still in its primitive condition and not separated. In both the above teeth the external cingulum is present, which shows their close relationship to *Telmatotherium*. The intermediate tubercles of these molars are much reduced. A peculiarity of the external lobes of both these teeth is that they are very thin and much worn. The slightly worn V of the anterior tooth exhibits the abraded surface of the enamel much thinner than in the permanent dentition. Because of this character and their rather low crowns I have referred them to the milk dentition. There is one mandible among the many in the collection which belongs to *P. paludosus*. In this jaw the last milk molar is present, and, as is usually the case, is as complex in its structure as is the permanent first true molar.

The Skull.—We are unfortunately entirely ignorant as to the form of the skull of *P. minor*, and, in fact, I have seen only one specimen of a portion of the skull of this species, that figured by Dr. Leidy on Plate XXIV, fig. 6 of his work. I have unfortunately not been able to examine the facial region containing the molars above referred to, as it is in a private collection. The specimen figured by Leidy[1] and the one which I have been able to examine contain the canine alveolus and the first three premolars. The form of this portion of the skull is high and narrow and resembles that of *Telmatotherium*. The canine alveolus is peculiar in form: instead of being rounded as is usually the case, the surface of the muzzle above the canine forms an oblique ridge which runs parallel to the maxillo-premaxillary suture; behind this ridge the surface of the maxillary bone is deeply hollowed out, and posteriorly becomes perfectly flat. The form of the postero-superior part of the premaxillary bone, which is preserved, leads me to conclude that this region was more slender and elongated than in *P. paludosus*. The superior termination of the nasal process of the premaxillary was above the second

[1]This specimen is now deposited in the collection of the Academy of Natural Sciences of Philadelphia.

premolar. The part of the palate preserved in this specimen shows this region to have been more elongated and narrow than in *P. paludosus*; the palate was also strongly arched as in the skull of *Telmatotherium.* A specimen of this species in the Princeton collection containing the malar insertion is interesting, as it shows the close relationship in form of this bone to that of *Telmatotherium.* As in the latter genus, the malar arises very abruptly from the cheek and diverges widely from it. Its superior face below the orbit is convex; its inferior surface is divided by a sharp longitudinal ridge. A small orbital process of the malar is present in this specimen, and posterior to this region, the malar is very thin and strongly compressed. The orbital floor, like that of *Telmatotherium*, is much elongated. Dr. Leidy, in his description of the facial specimen already referred to, says "the space behind the anterior abutment of the zygoma indicates a temporal fossa of large capacity"; and again "the orbit is low and is directed obliquely foreward and downward. In advance of the prominent anterior orbital margin the side of the face is nearly vertical. The infraorbital foramen is rather large, and is situated over the position of the last premolar."

Mandible.—The form of the jaw in *P. minor* closely resembles that of *P. paludosus.* The horizontal ramus is rather short, thick and deep below the last molar. The posterior border of the jaw is sinuous in outline, but this margin is not so strongly inflected as in the larger species. The ascending ramus is short and deep, its horizontal diameter on a line with the last molar is abbreviated in contradistinction to the elongation of this region in the jaw of *P. longirostris*, where the ascending ramus is widely prolonged posteriorly. The condyle is short and heavy; it is horizontal in position and separated by a shallow notch from the long and slender coronoid process. The masseteric fossa is broad and shallow, and is not separated by a ridge from the horizontal portion of the jaw. The angular portion is thin and everted. The jaw symphysis is very short and not procumbent. There is a single mental foramen situated below premolar 3.

Appendicular Skeleton.

Scapula, No. 10,277 A.—A lower portion of a smaller scapula than that of *P. paludosus* should probably be referred to *P. minor.* The specimen is very much damaged, so that is impossible to give all its characters. The general form of the scapula in this species closely resembles that of *P. paludosus.* The glenoid is deeply concave. The coracoid is very much broken, but its position and form is the same as in the larger species. The anterior border of the scapula above the coracoid is concave, and then rises suddenly to the strongly convex superior portion. There is a prominent tuberosity upon the posterior border, but it is much more reduced than in *P. paludosus.* The origin of the spine is nearer the glenoid border than in the larger species. The internal surface of the scapula is flat with a convex posterior portion. The dimensions of this specimen and its characters correspond very closely to one in the Academy of Natural Sciences of Philadelphia, which probably belongs to *P. minor.*

Femur, No. 10,347.—The femur of *P. minor* has the same length as that of the Tapir, its shaft, however, differs from the latter in being broader and heavier. The specimen under consideration has the great trochanter broken off, but from the basal portion I conclude it was probably of the same form as that of *P. paludosus.* The head of the femur is perfectly cylindrical. The neck is not well marked off from the shaft. The trochanteric fossa is flattened and deep. The anterior surface of the shaft below the head is strongly raised and terminates posteriorly in a rounded surface; upon this surface and just above the trochlear is a well marked fossa. This is present in the recent Tapir but is only slightly marked in the femur of *P. paludosus.* The lesser trochanter has about the same position on the shaft as that of the Tapir, although it is more prominent and longer than in the latter form. The surface of the shaft at the third trochanter is very broad compared with the length of the femur. The third trochanter is longer but not as prominent as that of the Tapir's femur; its distal portion is broad and strongly rugose. The distal extremity of the femur is broader in front and does not expand so much behind as in that of the Tapir; nor is the antero-posterior diameter as great as in the latter form. The trochlear surface is placed more underneath than in the latter and its surface is broad and short with the internal rim longer than the external. The intercondylar fossa is rather short and not as deep as in the larger species. The posterior face of the shaft is flattened and broader than that of the Tapir, and like that of *P. paludosus* it shows no fossa for the flexor perforatus muscle.

Tibia, No. 10,357.—The length and diameter of the shaft of the tibia coincides very closely with that of the Tapir. The proximal portion has its facets horizontally placed, whereas in the Tapir these facets are oblique to one another. The upper part of the tibial tuberosity is subdivided and the crest extends farther down on the shaft than in the tibia of the Tapir. The external notch for the extensor tendon is wanting, as in the tibia of *P. paludosus.* The distal trochlear surface is narrower than in the Tapir; its external process is oblique instead of being cut off squarely as in the latter genus. The posterior trochlear tuberosity is rather long, slender and more medially placed than in the Tapir. The external trochlear border is not deeply excavated and shows a straight facet for the fibula. The superior fibular facet is also well developed in this species.

Fibula, No. 10,352.—There is a fibula in the collection whose proportions correspond closely to those of the above tibia, but it was not associated with it. I shall, however, provisionally refer it to *P. minor.* This fibula is rather longer and stouter than that of the Tapir; its proximal portion is broad and flattened. Superiorly it shows a long and narrow facet for the tibia; its distal end is rather broad and heavy, and is bordered before and behind by a rather prominent styloid process. The astragalar facet is concave and shows an elongated lateral facet for the tibia. The articular extremity resembles more closely in form that of the Rhinoceros than that of the Tapir.

The Tarsus, (Pl. XIV, fig. 43.)—The tarsal bones are represented in the collection by a number of specimens, among them being a very finely preserved astragalus associated with the tibia, No. 10,357, already described. The measurements of this astragalus correspond very closely with those given by Leidy for this species. There is also another astragalus and calcaneum, No. 10,288 B, whose characters and measurements approximate closely to those above referred to. The foot in *P. minor* is narrower in comparison with its length than the foot of *P. paludosus*. This is especially noticeable in the form of the calcaneum and astragalus, which are very much lighter than in the larger species. The astragalus especially has the elongated form and rather slender neck so characteristic of that of *Limnohyops*. The size and proportions of the pes in this species are about the same as that of *Tapirus indicus*. The foot of the latter, however, is rather more elongated in proportion to its breadth than that of *P. minor*. The arragement, form and larger size of the tarsal facets, together with the shape of the cuboid, distinguish the tarsus of this species fiom that of the larger species of *Hyrachyus*.

Calcaneum.—The calcaneum is long and narrow; its articular portion being much narrower than that of *P. paludosus*. The distal portion of the tuberosity is wanting in this specimen but the basal portion of the same is preserved and is rather slender and compressed. The form of the calcaneal facets is nearly identical with that of the larger species; the sustentacular is, however, longer and slenderer. The inferior and sustentacular facets approach each other nearer than in *P. paludosus*. The inferior facet is long and sharply separated from the cuboidal face of the bone. The enboid facet is much narrower in comparison with its breadth than in the larger species; it is more nearly horizontally placed than in the latter species and slightly convex transversely. Quite a deep fossa separates the cuboid and the inferior facet from the sustentaculum. This calcaneum exhibits a well marked fibular facet.

Astragalus.—The astragalus of *P. minor* is nearly as long as that of *P. paludosus*, but it is much narrower; its trochlear portion being about one-third less in extent than in the larger species. The distal part is much elongated and slender. The form of the trochleæ is the same as in *P. paludosus*, but the height of the external trochlear is much less, and the posterior portion of it thins out very much behind, thus allowing the sustentaculum to penetrate upwards more than in the larger species. The fossa spoken of as occupying the external trochlear face of the astragalus of *P. paludosus* is only slightly marked. The most important difference in respect to the facets of the inferior surface of the astragalus is that the sustentaculum and inferior facets are continuous. The ectal facet is very deep and narrow; its anterior prolongation is not as great as in *P. paludosus*. The sustentaculum is very long and nearly straight; its proximal end is separated from the ectal facet by an oblique fossa which runs across the surface of the bone. Anteriorly and internally the sustentaculum is bordered by a prominent triangular ridge and the plane of the facet is oblique to it. A slight ridge is present at the junction of the sustentaculum with the cuboidal facet. The inferior facet of the astragalus is narrow; it terminates above and below by narrow extremities, its middle portion being the broadest. The form and length of the inferior facet of this species differ widely from that of *P. paludosus*. The inferior facet is continuous with the sustentaculum. The anterior face of the astragalus is slightly convex from above downward; its cuboidal margin is very oblique and this border joins the ental at the prominent inferior ridge of the astragalus already described. The astragalo-cuboid facet is wide above and narrows below to join the sustentaculum. Instead of running across the whole cuboid margin of the astragalus as in *P. paludosus* this facet in *P. minor* takes up only one-half of the whole length of this border, the lower portion being occupied by the sustentacular, which, owing to its oblique position, runs up on it. In *P. paludosus*, owing to the horizontal position of the sustentaculum, this facet is limited wholly to the inferior surface of the astragalus.

Navicular.—The characters of this bone as compared with those of the larger species are nearly the same, but its calcaneal face is more concave and the depth of the bone is greater in comparison to its width. The distal facets of the navicular are subequal. that for the mesocuneiform being slightly smaller than in *P. paludosus*. The facet for the entocuneiform is not well marked in this specimen. The cuneiform bones are wanting in this pes; they were probably wider and not as high relatively as in the larger species.

Cuboid.—The cuboid of *P. minor* is strikingly different in form from that of *P. paludosus*. It is a nearly square bone with the depth scarcely exceeding the width. The tuberosity of the cuboid is large, heavy and medially placed. The proximal face is subdivided by a very prominent ridge separating the rather large astragalar facet from the calcaneal. The astragalar facet is short and broad; its plane forming a more acute angle with that of the calcaneal than in *P. paludosus*. This portion of the cuboid bearing the astragalar facet is contracted off in a neck-like process quite different from that seen in *P. paludosus*. The calcaneal facet takes up about two-thirds of the distal face of the cuboid and is very broad and shallow. The distal face of the cuboid is remarkably flat and square; posteriorly it narrows, but its transverse diameter is relatively greater than in *P. paludosus*. The cuboid of *P. minor* can be readily distinguished from that of *Hyrachyus*. In the latter it is long and narrow with a small astragalar contact; its tuberosity is also more acute and laterally placed in the last named genus. There are two other cuboids in the collection which correspond in all their characters with those given for the above; they differ, however, in being much larger, and I think they probably belong to one of the large species of *Telmatotherium*. If this supposition is correct, the specimens are of interest, as they show the close relationship between *P. minor* and *Telmatotherium*. This affinity has also been proven from the dentition of *P. minor*.

Metatarsals, (Pl. XIV, fig. 44.)—The metatarsal region is shorter and more slender than in the larger species. The shape of the metapodials is, however, the same. The proximal part of metatarsal II is externally abruptly cut off and exhibits no entocuneiform facet; its shaft is broad and short. The facet on metatarsal II for the mesocuneiform is elongate and concave transversely. Metatarsal III is more slender than that of *P. paludosus*; its cuneiform facet is flat and oblique. The two facets on this metapodial for metatarsal IV are large and placed obliquely to each other; internally it shows no facets for metatarsal II. The distal articular surface of metatarsal III is more slender than in *P. paludosus*, and its tuberosities above the trochleæ are less conspicuous. Metatarsal IV corresponds closely to the corresponding bone in the larger species but is shorter and more slender; its shaft is strongly bent outwards, and its proximal facet for the cuboid is very flat.

PALÆOSYOPS LONGIROSTRIS sp. nov.

The type of this new species of *Palæosyops* is a jaw, No. 10,275, associated with a well-preserved radius, ulna, and two metacarpals. All these specimens are in the Princeton Museum. The type jaw of this species, with the parts of the skeleton associated with it, was referred by Scott and Osborn[1] to our *P. minor* (equal, in part, to *P. paludosus* Leidy). After comparing Leidy's type specimen with this jaw, I find that there is such a marked difference in some of its characters that I have to give it a specific rank. The following characters distinguish it from Leidy's type. 1. The great posterior extension of the jaw behind the last molar (this is a unique character of this jaw. I have not observed it in any other species of this subfamily). 2. The symphysis is much more elongated than in *P. minor*. 3. The lower border is straighter and less inflected than in *P. minor*. 4. The posterior tubercle of the last inferior molar is much larger than in the last named species. 5. The V's of premolar 4 are not so well developed as in *P. minor*, and there is also a well marked difference in the size of the first molars of the two species. In this jaw the first true molar is considerably smaller than in *P. minor*. The canine is very large and semi-procumbent, its position in the jaw resembling that of *T. hyognathus*.

SKELETON.

Radius and Ulna, No. 10,275. — The upper arm-bone of *P. longirostris* is wanting, but we are fortunate in having in the collection both bones of the lower arm, which belong to the same individual as the jaw which has been already described. This radius and ulna have been already described by Scott and Osborn, and I will merely insert a comparison with the same bones in *Limnohyops*. They are nearly of the same size as in the latter genus. The head of the radius is deeper and narrower than in *L. laticeps*. The external trochlear is much deeper and is not excavated by the radio-ulna facet as in the former species. The total length of the radius is much less than in *Limnohyops*. The internal ridge running from the external border of the bone upward to within a couple inches of the head is not so well marked in this species. The distal articular face of the radius is very large as compared with the length of the bone. The styloid portion of the articular face is not so oblique as in *L. laticeps*. The ulna is also proportionately short and heavy. The olecranon is different in form from that of *L. laticeps*, it being broader,

[1]Rept. Prin. Scien. Exped. for 1877, page 37–38.

and more irregular at its extremity. The sigmoid cavity is damaged in this specimen. It was broader and not as high as in *Lymnohyops*. The radial face of the ulna is concave from side to side and much broader, the oblique ridge upon its upper portion being more marked than in *L. laticeps*. The shaft of this ulna is broader, flatter and more angular than in the last named form. The relations of the distal extremity are about the same as in *L. laticeps*, this part being excavated upon its internal border and more set off from the shaft than in the latter. The facets of the distal extremity are the same in size as in *L. laticeps*. From the size and position of the bones of the lower arm of *P. longirostris* we may conclude that this species had a shorter and heavier anterior extremity than *L. laticeps*. This is farther shown in the size and form of the manus.

Manus.—The material relating to the manus is as follows: a right metacarpal II and IV found associated with jaw No. 10,275, and radius and ulna of the same number. In addition to the above material I have found a lunar and magnum which I refer to this species.

Lunar.—The lunar closely resembles that of *P. paludosus* in its general form and the position of its facets, although it differs from the latter in being much smaller. The general proportions of the lunar are broad and low; its vertical axis exceeding somewhat the transverse. The depth of this lunar is short compared with its other dimensions. The posterior part of the superior facet is much lower than the anterior, being strikingly so as compared with *P. paludosus*. The lunar-magnum facet is larger proportionately than that of the larger species and approaches nearer the median axis of the bone. The lunar-unciform is very large but not as deeply concave and more obliquely placed than in *P. paludosus*. The lunar in this species also resembles that of the largest species in having only a slight prolongation of its inferior face between the magnum and unciform.

Magnum.—The form of the magnum is rectangular; its transverse axis only slightly exceeds its vertical. The magnum-lunar facet is more nearly vertical than in *P. paludosus*, and the anterior part of the superior face is more horizontal, with the pivot less ascending than in the latter. The magnum-metacarpal III facet is deeply concave and not overhung by a beak-like process as in *P. paludosus*.

Metacarpals.—The second metacarpal is in a good state of preservation; it is much shorter than that of *P. paludosus* but proportionately broad in comparison with its length. Its distal extremity is broad and heavy. The facets of the proximal end are the same as in *P. paludosus*, the superior one being not so concave as in the latter. Unfortunately the projecting portion of this metacarpal which articulates with the magnum is broken, but otherwise the shape of the proximal extremity closely resembles that of the larger species of this genus. Only the proximal part of metacarpal IV is preserved. It is quite massive and the facet of its superior face rather more oblique than in *P. paludosus*. Its radial facets are unusually large for the size of this metapodial, especially the posterior one. The facets for the metacarpal V are also large and inclined to each other. The size and proportions of the above metatarsals indicate that *P. longirostris* had a short and broad manus like that of *P. paludosus* but much shorter. It also resembles the latter species in having wide-spreading digits to the manus. The two carpal bones that have been just described also point to a carpus with a considerable transverse breadth and a much shorter vertical diameter.

MEASUREMENTS OF LOWER JAWS.

	P. minor.	P. longirostris.
	M.	M.
Total length from posterior border symphysis to posterior border of ramus	·250	·270
Length of ascending ramus behind molars on a horizontal line	·102	·130
Depth of ramus below last molar	·068	·066
Length of entire inferior molar series	·164	·155
Length of true molars	·100	·091
Last molar { trans.	·022	·020
Last molar { ant.-post.	·041	·042

TELMATOTHERIUM.

(Syn.—*Leurocephalus* S. and O.)

This genus was established by Marsh[1] in 1872 the type species being his *T. validus* in the Yale College Museum. Later Scott and Osborn[2] described their genus *Leurocephalus*, which, as I have already stated, I find upon comparison with Marsh's type specimen to be the same as *Telmatotherium*, of which it is therefore a synonym.

Generic characters. Dentition.—The upper incisors of this genus form a continuous series and increase in size from within outward. The basal portion of their crowns is nearly circular in section, with a posterior and very prominent basal ridge. The free extremity of the crown is pyramidal in form, being deeply excavated posteriorly. The canines are long and slender with very prominent anterior and posterior cutting edges. The canines in this genus are very different in form from those of *Palæosyops* where they are nearly round in section and without cutting edges. A pre- and post-canine diastema may be present. The crowns of the superior premolars are higher, and they are provided with sharper cutting lobes than in *Palæosyops*. The external lobes of all the premolars are straight, and the last does not show the median buttress which is so characteristic of some species of *Palæosyops*. The first premolar is a two-fanged tooth with an elongated and compressed crown; a rudimentary posterior heel may be present. In *Palæosyops* premolar 1 is generally a simple cone. The second premolar may be provided with a well developed internal lobe, or

[1]Am. Jour. Sci. and Arts. 1872, vol. 4.

[2]Princeton Scientific Expedition of 1877, Pub. Sep. 1st, 1878.

this lobe may be rudimentary. The intermediate conules of the premolars may be wanting, or, as in one of the species of this genus, they may be slightly developed on premolars 3 and 4. The true molars have their axes about equal, thus producing a square-shaped tooth; this is especially noticeable in the last superior molar, whose internal border is square and not obliquely cut off as in the same tooth of *Palæosyops.* The crowns of the superior molars are very high as compared with those of *Palæosyops.* The external V's especially are broad, high and with sharp cutting lobes. The width between the buttresses of the external V's is considerable in this genus, and the median buttress is strongly constricted off. The anterior buttress is not so strongly developed as in *Palæosyops.* The median valley between the external and internal lobes is very deep. The external cingula of the molars may be prominent. The two anterior molars are each provided with two internal cones, which are equal in height. In the last molar the protocone is always present, but the hypocone of this tooth is totally absent in one species, and in the other is merely represented by a very small conule. The transverse diameters of premolar 4 and molar 1 are nearly equal, whereas in *Palæosyops* there is a marked difference in the transverse diameter of these two teeth.

Lower jaw.—The inferior incisors in this genus are more procumbently implanted in the alveolus than they are in *Palæosyops* and they are said to be more compressed and laniariform than in the latter genus. The lower canines are large, and a considerable post-canine diastema is present. The first lower premolar is slightly separated from the second, and it is more compressed and elongated than in *Palæosyops.* The crescents of the last two premolars are more strongly marked than in *Palæosyops.* The protoconid of premolar 1 is twice as high as its metaconid.

In the last premolar the two V's are more developed than in *Palæosyops*, and they approach more closely the complexity of the first true molar than they do in that genus. The true molars are provided with much higher crowns, and their antero-posterior diameter is much more extensive than in *Palæosyops.* The crests of the molars are also much higher, and their V's much more strongly expressed than in *Palæosyops.* The posterior tubercle of the last lower molar in this genus is largely developed, its transverse diameter being nearly as great as that of the whole molar. This tubercle is more laterally placed than in *Palæosyops* and is provided with a well marked median valley and two lateral crests.

Skull.—As far as known, the skull of this genus is narrower and much higher than that of the allied genus *Palæosyops*; this applies especially to the facial region. The nasals are long and strongly arched laterally. The form of the premaxillaries is highly characteristic. They are strongly compressed, with a much elongated median symphysis, in this respect differing widely from the premaxillaries of *Palæosyops.* As far as I have investigated, I have found no transition forms between these two genera as far as the shape of the premaxillaries is concerned. The palate is much elongated and strongly arched. The malar insertion is characteristic, being quite different from that of *Palæosyops.* The zygomatic arch is nearly straight, slender and approaches very closely in form that of *Diplacodon.* The orbit is quite large and the great antero-posterior extent of the orbital floor is characteristic of *Telmatotherium.* The axial and appendicular skeletons are unknown.

Synopsis of the Species of the Genus Telmatotherium.

There are but three known species of this genus, with a number of interesting transitional varieties.

1. Inferior diastema large . . . . . . *T. hyognathus.*
2. Inferior diastema small.
   a. Superior premolar 2 with a rudimentary internal lobe *T. cultridens.*
   b. Superior premolar 2 with a well developed internal lobe *T. validus.*

Telmatotherium validus.

I have already stated in my preliminary paper that the superior molars figured by Cope[1] as belonging to *P. validens* should be really referred to this species. The fact that in this series of molars the second superior premolar has a well developed internal lobe would include it under the specific characters of *T. validus.* Considerable variation exists in the premolars of this species as regards their internal cingula, and I consider a complete or incomplete cingulum as having no real specific value, at least as applied to this subfamily. I have treated this character under the head of *P. paludosus,* and showed its wide variation in that species. I still have another illustration of the wide variability in the character of the cingula in *T. validus.*

Dentition.—Most of the characters which I shall give for the dentition of *T. cultridens* will apply equally well to *T. validus,* so that it is only necessary to enumerate the specific characters which distinguish the latter from *T. cultridens.* The teeth of *T. validus* are considerably larger than those of *T. cultridens,* especially the diameter of the premolars. The second premolar is much larger antero-posteriorly than that of *T. cultridens;* it is provided with a large internal lobe and its internal basal cingulum is complete. These characters we see at once, especially the largely developed internal lobe of premolar 2, are very different from those of *T. cultridens.* The other premolars have high crowns and well marked vertical folds, the latter character being especially prominent on the external lobes of the last superior premolar. The last two superior premolars have slightly marked protoconules and their internal cingula are incomplete. In the series of the superior molars of this species figured by Cope all the premolars have complete internal cingula. The external cingula of all the true molars are not as strongly marked in this species as in *T. cultridens,* although in Cope's examples the external cingula are more marked than in Marsh's type specimen. In contrast to the other species of this genus the intermediate conules are well developed. The first molar has a well developed protoconule; the second molar has also this conule developed. The pos-

[1]Tertiary Vertebrata, Plate LI, fig. 1.

terior part of this tooth is broken off in Marsh's specimen, so that the presence of a posterior intermediate cone is uncertain. In the last superior molar in Marsh's example the protoconule of one side is well developed, without a metaconule, but on the opposite tooth the metaconule is well developed. There is no trace of rudimentary hypocone on the last superior molar.

TELMATOTHERIUM CULTRIDENS.

(Syn.—*Leurocephalus cultridens* S. & O.[1])

Dentition, (Pl. XII, figs. 12, 13).—The basal ridges of the incisiors are very strongly marked. The external incisor is a very large canine-like tooth, and is separated by quite a long interval from the canine. The canine is long and slender, its external face is strongly convex, the posterior being concave; the anterior and posterior cutting edges of the canine are sharply marked off from the body of the tooth and extend along the whole length of the same. The first premolar shows a postero-longitudinal ridge, which has on its internal side a small tubercle in connection with the internal cingulum of the tooth. There is no rudimentary lobe on the first premolar anterior to the principal lobe. In the following premolar its external face is nearly straight, high and not separated by a median buttress. The vertical folds and cingula of the anterior lobes of the premolars are strongly expressed. The second premolar has only a rudimentary internal lobe which consists of an elongated ridge with a small, distinct, posterior tubercle. At its posterior portion the internal cingulum is distinct from the ridge referred to, but anteriorly they coalesce and run together as far as the anterior buttress of the tooth. The internal lobes of the last two premolars are slightly concave on their external sides, and give off laterally crests which do not reach as far as the external lobes. The last two premolars have strongly marked internal basal cingula which are complete, the internal median portion of the cingula rising upon the inner face of the cone of the teeth. There are no traces of intermediate conules upon the superior premolar series.

Superior molars.—The external cingulum of all the true molars is strongly marked in *T. cultridens*, and it extends all across the face of the teeth and is prolonged upon the anterior and median buttress. The median buttress is very large, and its superior portion is shut off entirely from the median valley of the molar. The anterior cingulum of the molars is large, its inner half especially having a considerable vertical height. All the molars have well developed cingula, that of the last molar being complete. The intermediate conules are unusually reduced; on the first molar there is only a very small protoconule; the second and last molars are totally without intermediate conules. The internal cones of the molars are very high and sharp as compared with those of *P. paludosus*. The hypocones of molars 1 and 2 are smaller, and placed nearer to the posterior internal angle

[1]Rep. Prin. Scien. Exped. of 1877, 1878, page 42.

of the teeth than in the larger species of *Palæosyops*. In the last molar a very rudimentary hypocone is present. The position of this cone certainly corresponds with the large hypocone found in *Limnohyops laticeps*, and I believe it is placed too far internally to be a metaconule. The posterior internal cingulum of the last molar bordering the metaconule is large but is distinctly separated from it, and extends along the posterior border of the tooth as far as the external lobes.

Lower jaw.—The alveolus for the lower canine is as large as that for the upper, so that probably these teeth were equal in size, as in *P. paludosus*. The post canine diastema is quite large and the diastema between premolar 1 and 2 is very small. The first inferior premolar has a well developed heel and a slight indication of an anterior tubercle. The protoconid of the second premolar is unusually large and prominent; it is very much higher than any of the other cones of the following premolars. In the third premolar the V's are not well expressed; the anterior crests of the anterior lobes are large but run nearly directly forward. In the posterior V of this tooth neither the anterior or posterior limb is well marked. The last premolar differs from the one just described in having strongly marked double V's, both of which are well developed and have their anterior and posterior crests high and continuous. As in all the species of this subfamily the entoconid of the last premolar is wanting, but the crest running to it in this species is large, and shows a decided advance in structure over the condition of this tooth in *P. paludosus*. All the premolars of this species have traces of an external cingulum, and in the last two an anterior and posterior cingulum are well seen. All the cones of the inferior true molars are very high and sharp, the external and median valleys separating the latter being very deep. The posterior tubercle of the last inferior molar is large; its vertical height is equal to that of the anterior lobes of the molar. The size of the incisor alveolus which is preserved in a jaw in the collection, indicates that the inferior median incisor was the largest of the three; the external, judging from the size of its alveolus, being very small or indeed rudimentary.

Skull, (Pl. X, fig. 3).—The facial region of the skull of *T. cultridens* has been figured by Scott and Osborn in their report of 1877. This specimen contains also the greater part of the lower jaw, bearing the teeth. There is one other fragment of a skull belonging to this genus in the collection, which from its large size seems to belong to *T. validus*. Owing to the lack of material and the damaged condition of the specimen, it is impossible to give the exact dorsal contour of the skull, although the parts preserved indicate that the facial region was very high and strongly compressed. The posterior part of the malar insertion is flat and elongated. Two fragments of the roof of the skull belonging to a specimen of this species in the collection indicate that the posterior narial and interorbital regions were flat and rather narrow. There is no frontal depression in the skull of *T. cultridens* like that of

P. paludosus. The occipital contour was probably very similar to that of *P. megarhinus*, the posterior portion of the skull rising gradually from between the orbits to the occipital region.

Premaxillaries.—The form of the premaxillaries is the most important character of the skull of *T. cultridens.* These bones differ from those of *P. paludosus* in being much higher and more elongated. Their anterior contour is ascending and is cut off abruptly, so that this portion presents an elongated triangular symphysis which articulates with its fellow of the opposite side and has a prominent anterior keel. Externally, the superior border of the premaxillaries form an angle with the anterior, and this border slopes gradually upward, its posterior limit being above the first premolar. The superior border of the premaxillaries is more elongate in *T. cultridens* than in *P. paludosus* owing to the extension of these bones antero-posteriorly. When the premaxillaries are viewed from above they present a triang-

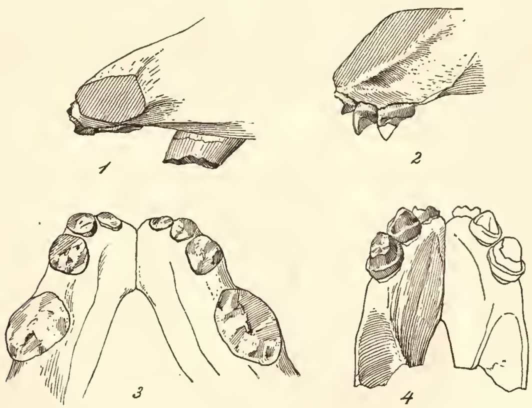


FIGURE 7.—Internal and ventral view of the premaxillary region.
1, 3. *Palæosyops paludosus.* 2, 4. *Telmatotherium cultridens.* One-half natural size.

ular outline, their prominent and elongated median symphysis being conspicuous; their surface on each side of the median keel is concave, but above and below this depression the surface of the bone becomes rounded, and continues the concavity as far as the slight diastema between the incisor and canines, where the surface of the premaxillaries is slightly concave. The form of the premaxillaries is so characteristic of this species, that it at once distinguishes it from *Palæosyops paludosus*, where these bones are short, rounded and without any anterior keel and have a very short, round and slightly oval symphysis.

Nasals.—The nasals are strongly arched laterally and much elongated, their superior surface being convex and narrow; at their junction with the frontals they are flat and wider than at their anterior portion. The extremity of the nasals is not expanded. The inferior border of the nasal notch is well preserved in this skull and shows it to be nearly horizontal in position, and more elongate than the skull of *P. paludosus*. The superior termination of the nasal notch is above the second premolar.

Maxillary.—The vertical plate of the maxillary is much elongated and high above the malar region. The infraorbital foramen is large, placed above the anterior border of the first true molar and is more exposed than in *P. paludosus.* The form of the alveolar border of the maxillary is very different in this species from that of the larger species of *Palæosyops*. In *T. cultridens* this border is strongly convex and the anterior portion bearing the canine is much higher than the posterior alveolar region, thus making the anterior facial region rise strongly above the malar insertion. The horizontal lamina of the maxillary, forming a part of the palate, is much larger and narrower than in *P. paludosus,* the narrowness being especially noticeable in the premaxillary region. The inferior surface of the palate is strongly arched; this is especially marked when the facial region is viewed from the front. The superciliary border of the orbit is much more elongated and higher than in *Palæosyops;* the floor is very broad and long, and its transverse and longitudinal diameters are nearly twice as great as those of *P. paludosus*.

Malar.—The malar insertion is peculiar in *T. cultridens.* It arises abruptly from the cheek with an anterior rounded border; its external face is provided with a blunt keel separating the bevelled superior surface from the narrow and sharp inferior portion. The orbital process of the malar is not well marked in this skull, but the superior process from the frontal bordering the orbit posteriorly is large and not acuminate. The temporal ridge arising from the latter is not so oblique in its course as in *P. paludosus,* indicating that these ridges were farther apart than in that species, the forehead consequently being flatter. The portion of the malar posterior to the orbit is very small and oval in section. The anterior part of the zygomatic process of the squamosal is preserved, and shows this portion of the arch to have been straighter and narrower than in *P. paludosus;* its external face is flat and its posterior portion narrow in form as in *P. megarhinus*. The zygomatic arch, as a whole, in *T. cultridens* is much lighter and more horizontal in position, and it does not project so widely from the skull as in *P. paludosus*. It is interesting to note that the zygomatic arch of *Diplacodon elatus* is slender and straight, and much more closely resembles that of *Telmatotherium* than that of *Palæosyops.* This supports the view that *Telmatotherium* and not *Palæosyops* is the immediate ancestor of *Diplacodon.*

Mandible.—The mandible is longer and straighter than that of *P. paludosus.* This applies particularly to the lower border of the jaw, which is perfectly straight from below the last true molar to the anterior premolar region, the portion of the jaw in front of the latter region being arched upward and forming quite an angle with the horizontal part. In *P. paludosus* there is no such angular portion to the jaw, and the chin is more rounded than in *T. cultridens.* The middle third of the posterior border of the jaw is not inflected in *T. cultridens*, but the border is thick, convex and straight. The internal face of the jaw is of more equal diameter throughout than in *P. paludosus*, it having no long and convex border just below the molars as in that species. The symphysis

TEETH AND JAW MEASUREMENTS OF TELMATOTHERIUM.

Upper Jaw.	T. validus.	No. 10,184.	T. cultridens.	P. vallidens.	T. hyognathus.
	M.	M.	M.	M.	M.
Entire molar series	·220	– –	·190	– –	– –
Length of true molars	·130	– –	·111	– –	– –
Length of premolars	·090	– –	·085	– –	– –
Premolar II, trans.	·020	– –	·019	– –	– –
Premolar II, ant.-post.	·025	– –	·021	– –	– –
Premolar IV, trans.	·032	– –	·027	– –	– –
Premolar IV, ant. post.	·028	– –	·023	– –	– –
Molar I, trans.	·037	– –	·031	– –	– –
Molar I, ant.-post.	·038	– –	·033	– –	– –
Molar III, trans.	·050	– –	·046	– –	– –
Molar III, ant -post	·051	– –	·045	– –	– –
Lower Jaw.					
Entire molar series	– –	·178	·202	– –	·242
Length of true molars	– –	·105	·121	– –	·141
Length of premolars	– –	·075	·077	– –	·100
Premolar II, length	– –	– –	·023	– –	·024
Premolar II, height	– –	– –	·021	– –	– –
Premolar IV, trans.	– –	– –	·015	– –	– –
Premolar IV, ant.-post.	– –	– –	·023	– –	– –
Molar I, ant.-post.	– –	– –	·029	– –	– –
Molar I, trans.	– –	– –	·018	– –	– –
Molar III, ant.-post.	– –	·048	·055	·057	·063
Molar III, trans.	– –	·018	·022	·022	·026
Molar III tubercle, ant.-post.	– –	·014	·015	– –	·018
Molar III tubercle, trans.	– –	·013	·014	– –	·017
Length of diastema before pm. I	– –	– –	·012	– –	·030
Length of diastema behind pm. I	– –	– –	·005	– –	·017
Jaw.					
Total length of jaw	– –	·345	·380	·420	·470
Depth below last molar at middle	– –	·060	·070	·083	·088
Length of symphysis	– –	·085	·100	– –	·122
Breadth of symph. between pm's I	– –	·040	·050	– –	·062
Width of lower incisors	– –	– –	– –	– –	·075

is more elongated and horizontally placed than in *P. paludosus*, but not as much so as in *T. hyognathus*, which is the largest species of this genus. The region between the premolars and canines is strongly compressed, and the diastemas present are much smaller than in the larger species. The position of the posterior limit of the symphysis is the same in this species as in *P. paludosus.* The dental foramina are situated below the third premolar. The description of the jaw of *T. cultridens* has been largely taken from mandible No. 10,027 in the Princeton collection, which is associated with the facial portion of the skull already described; and also from another specimen, No. 10,361, better preserved than the former, which I consider as belonging to this species.

TELMATOTHERIUM HYOGNATHUS.

(Syn. *P. hyognathus* S. & O.[1])

The type of this species which was partially described by Scott and Osborn, is a finely preserved jaw, No. 10,273 in the Princeton collection. There is also another portion of a mandible, No. 10,274 in the collection, which I think should be referred to this species. Both the jaws are from the Washakie Eocene, and as yet I have not met with the species from the Bridger proper.

Dentition, (Pl. XI, figs. 10, 11).—I have referred jaw No. 10,273 to the genus *Telmatotherium* on account of the characters of the last molar, which agree in all essential points with those already described as belonging to *T. cultridens,* namely, a high crown, with the posterior tubercle of the last inferior molar a well developed lobe. The incisors are of the Telmatotheroid pattern and are unusually procumbent, as they are nearly horizontally implanted in the jaw. They are of uniform size throughout, their crowns are very wide and low, excavated posteriorly, and show a well marked internal basal cingulum. There is no precanine diastema. The canines are very peculiar in form, and differ in this respect greatly from those of *P. paludosus.* They are implanted very obliquely, and as a consequence diverge much more from the jaw than in any other allied species. The crown of the canine, instead of being much elongated, round in section and strongly pointed as in *P. paludosus,* is short and rather broad, with a stout extremity. The external face of the canine is strongly convex, whereas the inner face is concave, the external half of the crown being bent away from the main axis of the tooth, thus leaving a broad inner basal portion which is much abraded in the type specimen. The peculiar form of the canines of this species is less well marked in jaw No. 10,274, whereas in jaw No. 10,273 the inner basal portion is not sharply marked off as in the other specimen. The diastema between the canine and premolar 1 is very long, being equal to twice the length of the diastema behind the first premolar. The section of the first premolar shows it to have been a round tooth and its crown was probably much elongated. The second premolar is considerably worn, but enough remains to show that its protoconid was very large and high. This tooth differs from that of *T. cultridens* in having a well developed anterior tubercle; the hypoconid is large, but not nearly as high as the protoconid. The remaining premolars posterior to the last are all badly damaged in jaw No. 10,273, whereas in the other example of this species premolars 3 and 4 are intact but much worn. The posterior V of the third

[1] Uinta Mammalia, page 513.

premolar of this jaw appears to be more developed than in *T. cultridens* and the last premolar differs more from the third in size than in the smaller species of this genus. It is difficult to decide whether the last premolar in this species is really as complex as the first true molar, as its crown is much abraded, although the posterior inner angle of the same is not as much worn off as the rest of the tooth, which appears to lack any signs of an entoconid. If this is the correct interpretation none of the premolars in this species are as complex in their structure as the true molars. In the best preserved jaw the last inferior molar has a very high crown with a long antero-posterior diameter. The posterior tubercle of the last inferior molar is large and laterally placed; its anterior crest was strongly developed, the posterior one being much less so. The large size of this jaw and the peculiar characters of its symphysis, would naturally lead us to compare it with the jaw of *Diplacodon*. The isolation of the first premolar in *T. hyognathus* is a character not found in *Diplacodon*, in which the first premolar is placed close to the second, a long single diastema between the former and the canine intervening. The length of the symphysis in *T. hyognathus* is probably greater compared with the size of the jaw than in *Diplacodon*, (see table of comparative measurements.) The anterior portion of the jaw in *Diplacodon* is not nearly so horizontal in position as in *T. hyognathus*. The wide spreading canine and nearly straight outline of the incisors correspond very closely in character to those of *Diplacodon*.

Mandible.—The jaw of *T. hyognathus* is much elongated and narrow. The region of the symphysis is very Suilline in character; that is to say, anterior to premolar 2 the jaw is more nearly horizontal than in the other species of this subfamily, and this portion forms a much larger angle with the posterior two-thirds of the horizontal ramus than in the other species. The horizontal ramus differs from that of *Sus* in the fact that it is more slender, and in the region below the second premolar being only about one half the depth that it is below the last molar, whereas in *Sus* these vertical diameters are about equal. The posterior border of the ramus is straight and presents no inflection and posterior concavity so characteristic of the jaw of *P. paludosus*. The region of the angle is very broad, thin, and strongly everted. The inferior border of the angular portion of the jaw is turned inward. The coronoid portion is destroyed. The alveolar border is straight, and a considerable space intervenes between the tubercle of the last inferior molar and the ascending portion of the ramus. The characters of the symphysis of the jaw are striking. The symphysis is much more elongated in *T. hyognathus* than in any other species of this subfamily; its posterior limit is only slightly more extended than in other species. The symphysis commences at the middle of premolar 3, but the anterior portion in front of premolar 2 is extremely elongated and narrow. Between the second premolar and the canine the jaw is very much compressed; so much so, that when viewed from above there is a striking difference between the transverse diameter of this portion, and that of the middle region of the jaw. The narrowest part of the mandible is just in front of the second premolar; from here anteriorly it widens, and between the canines the jaw is flat and strongly depressed. We see the beginning of this elongation of the jaw in the smaller species of the genus; thus, in *T. cultridens* the diastemas anterior and posterior to premolar 1 have appeared, but they are not so strongly marked as in this species. In *P. paludosus* on the other hand very much reduced diastemas appear to be the rule. In both examples of the jaws of *T. hyognathus* the mental foramina are double; the anterior being situated under the second premolar, while the posterior is much smaller and placed between premolars 2 and 3.

COMPARATIVE MEASUREMENTS OF LOWER JAWS.

	T. hyognathus.	P. vallidens.	Diplacodon.
	M.	M.	M.
Distance from canine to dental foramen	·350	*·314	
Length of inferior molars, total	·140	·145	·160 [1]
Last true molar, ant. post.	·063	·057	
Last true molar, trans.	·026	·022	
Length of symphysis	·122		·180

LIMNOHYOPS.

(Syn. embraces *Palæosyops* as employed by Marsh, *Limnohyus* as employed by Leidy and others.)

The type of this genus was described by Marsh[2] in 1872 under the name of *Palæosyops laticeps.* He also at that time described his *Limnohyus robustus.* The former genus was characterized by having the last superior molar with two internal cones, and the latter by having this tooth with only one internal cone. Dr. Leidy,[3] previously to Marsh, had fully characterized the genus *Palæosyops*, giving the characters of the teeth and skeleton quite fully, his description clearly showing that *Palæosyops* belongs to the Perissodactyles. Dr. Leidy, in his report for 1873, adopts Marsh's name of *Limnohyus* for those forms which have the last upper molar with two internal cones, but by the priority of Leidy's determination, both of the genera described by Prof. Marsh had become synonyms, and it was not until 1890 that the latter[4] gave his two-coned type of molar the name *Limnohyops.*

Dentition.—The characters of the teeth in *Limnohyops* are more closely related to those of *Palæosyops* than to those of *Telmatotherium,* although the smaller species, *L. fontinalis,* has molar characters which, in some respects, point to its affinity with *Telmatotherium.* The crowns of the molars in *Limnohyops,* like those of *Palæosyops,* are low and broad, with shallow valleys, the diameter of their transverse axes exceeding that of the antero-posterior. The external V's of the molars are rounded

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[2]Am. Jour. Sci. and Arts, July, 1872.

[3]Hayden's Prem. Rept. Geol. Surv. of Montana, etc., April, 1872.

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and not as angular as in the genus *Telmatotherium*. The buttresses of the molars are not so strongly developed as in the latter genus. In both species of *Limnohyops* the molars are without external cingula. On the true molars both intermediate tubercles may be fully developed in one species, while in the other they are much less so. The internal cones of the molars are angular and may be connected with the external V's by slightly marked transverse ridges. In the last superior molar the hypocone may be large and equal to the height of the protocone, or reduced and much smaller than the protocone.

Skull.—The skull is more elongated and primitive in form than in *Palæosyops*. From above downward it is much depressed, especially so in *L. fontinalis*. The facial portion of the skull is short in comparison with the much elongated cranial part. The nasals are long, narrow and of the same width throughout. The premaxillary bones resemble closely those of *Palæosyops*, being short and compressed, with a small round symphysis. The occipital crests may be greatly developed, much more so than in any other genus of this subfamily. The auditory processes are distinct and the zygomatic arch is broad and heavy. The brain was probably very small and much less in bulk than in the allied genus *Palæosyops*.

The Skeleton.—Portions of a skeleton which I believe to belong to this genus, show the following characters in addition: The scapula is more slender than in *Palæosyops*, with its spine oblique to the plane of the glenoid cavity. Bones of arm and forearm more slender than in *Palæosyops*. Carpus highly specialized, the lunar having the magnum facet nearly vertical. Magnum high and narrow. A large contact between the metacarpal III and unciform. Carpus more nearly of the mesaxonic type than in *Palæosyops*. Fifth metacarpal well developed. Tarsus more elongate and slender than in *Palæosyops*; facets of astragalus and calcaneum continuous. There may be a contact between the cuboid and metatarsal III. There are only two species of this genus at present known; their characters are given in the following table:

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A. Size large.

Hypocone of superior molar III one-half the size of protocone, *L. laticeps*.

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The description given by Prof. Marsh[1] of the dentition of this species is exceedingly brief, and he fails to point out some of its most important dental characters. Dr. Leidy,[2] in his report for 1873, figures a superior molar which he, correctly I think, refers to *P. minor* (his *P. paludosus* in part), but having consulted Prof.

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[2]Rep. U. S. Geol. Surv. of Ter. for 1873, Plate XXIII, fig. 13.

Marsh about his identification, the latter referred this tooth to the last upper molar of his *L. laticeps*. I cannot understand why he referred the tooth to *L. laticeps*, as it is a loose molar, and certainly has not the characters of *Limnohyops*.

Superior Dentition.—The upper molars form a complete series. The incisors increase from within outward like those of *P. paludosus*. Marsh says "the canine is large and broadly oval at its base." In this respect it agrees in form with the canine of the larger species of *Palæosyops*. In Marsh's type specimen the external lobes of the anterior premolars are badly damaged. Those of the posterior have their crowns low with well marked internal basal cingula, which are incomplete. In the last premolar the paracone is much larger than the metacone; this is a character of the tooth quite different from that of *P. paludosus*, where the external lobes of the last premolar are generally equal. A conspicuous vertical fold is present upon the paracone of the last superior premolar. The last superior premolar of *L. laticeps* is distinguished from that of *P. paludosus* by the presence of a well marked protoconule. The presence of an intermediate conule upon the premolar series in any species of this subfamily is a very rare occurrence, and is seen in only one other species, viz: *Palæosyops borealis*. In *L. laticeps* the transverse diameter of the last premolar is nearly equal to that of the first molar. All the true molars have low crowns and shallow median valleys; and the transverse axes of the molars is greater than their antero-posterior axes. The external V's have the same general characters as the molars of *P. paludosus*. The external faces of all the true molars are without cingula, and the internal cingula of the molars are not as strongly developed as in *P. paludosus*. The protoconule and metaconule of molars 1 and 2 are unusually large, and in the occurrence of the last named intermediate it differs from the molar of *P. paludosus*, in which a metaconule is absent. On the last true molar there is a well marked protoconule. The transverse ridges connecting the internal cones with the external lobes are plainly marked, but they are very low and only slightly constricted off from the surface of the enamel. In the first and second upper molars the transverse ridges are more developed than in the last superior molar. The internal cones of the first two molars are like those of *P. paludosus* being equal in size, but in the last upper molar the hypocone in *L. laticeps* is much smaller than the protocone. As already mentioned under the description of *P. paludosus*, certain varieties occur in that species, characterized by the presence of a rudimentary hypocone upon the last upper molar; this is due to the fact that at the posterior internal angle of the molar the cingulum is raised vertically above the surface of the tooth and forms a rudimentary cone. In some cases a rudimentary hypocone, or perhaps it may be a metaconule, is developed. The first stage of the development of the hypocone is the separating of the cingulum from the posterior intermediate conule; its further development from the cingulum forms a very rudimentary hypocone. The direct transition from *P. paludosus* to *Limnohyops laticeps* would unite these genera, but with the other species of *Limnohyops*, viz: *L. fontinalis*, where the internal cones of the last upper molar are large and equal in height, there is no such transition. For the present, therefore, and until more abundant material is discovered, it will perhaps be better to leave those forms in which the last upper molar has two internal cones in the genus *Limnohyops*, with the understanding that this genus should not have a generic value equal to that of *Palæosyops*. A case parallel to the above is that of *Titanotherium* Leidy and *Diconodon* Marsh. Prof. Osborn[1] holds that the latter genus cannot be separated from the other, because the hypocone of the last upper molar is found in all stages of development in the different species of these two genera. He found the presence or absence of the first lower premolar in *Titanotherium* a very variable character, which is not, however, the case in *Palæosyops* and *Limnohyops*, where both genera have the same number of teeth above and below.

Skull (Pl. XI, figs. 8, 9).—The Princeton collection contains a very fine occipital portion of a skull of *L. laticeps*. It was collected in the Bridger basin and is one of the best preserved skulls in the museum. The cranium was referred by Scott and Osborn, in their report for 1877, to *P. minor*, but I find upon comparing it with Marsh's original type of *L. laticeps*, that it should be referred to *Limnohyops*. The measurements of this cranium are considerably less than those of Marsh's type, and it may possibly represent another species, although the height of the occipital crests and the width of the same region are very variable characters, and may differ widely in their dimensions in the same species, as we can readily prove by examining, for example, a number of skulls of the genus *Ursus*.

General form (Fig. 2, p. 289).—In general form the skull differs from that of *P. paludosus* or *P. megarhinus*. Its dorsal contour is very much like that of the Rhinoceros, being slightly depressed in the frontal region and rising gradually to the occiput, while the latter region is much higher than the anterior portion of the skull. The occiput is provided with a great development of the lambdoidal and sagittal crests, which are much heavier than in any other species of this subfamily. The nasal region is rather elongated and slender and closely resembles that of *P. lævidens* in the form of its nasals. The skull as a whole is more elongated and depressed and has a shorter facial region than that of *P. paludosus*. The orbit is rather small and placed well forward, its anterior termination being over the anterior border of the second molar. The floor of the orbit in *L. laticeps* is short as in *P. paludosus*. The orbit is separated from the temporal fossa by a well marked post-orbital process. The temporal fossa is rather low, much elongated and very deeply excavated, more so in comparison with the size of the skull than in any other species of this subfamily. The zygomatic arch is heavy and wide spreading. We may add that the projecting processes of the cranium are exceedingly strongly developed. The occiput is rather low, broad, with wide projecting paroccipital processes.

[1]Preliminary account of the Fossil Mammals from the White River Formation, etc., page 158. Bull. Mus. of Comp. Zoology, 1887.

The basal region of the skull, compared with that of *P. megarhinus*, is shorter and broader.

Premaxillary region.—The form of the premaxillaries is nearly identical with that of *P. paludosus*; they are strongly convex anteriorly, without a prominent keel. The premaxillary symphysis is short and round as in *P. paludosus*. The horizontal maxillary processes of the premaxillaries are well developed and they form a septum between the two incisive foramina.

Nasals.—The nasals are much elongated, narrow and descending; laterally they are strongly arched, and their anterior extremities reach as far forward as the premaxillary symphysis. They differ from the nasals of allied species in being of the same extent transversely throughout their course. The ends of these bones are narrow, abruptly rounded and show no signs of the transverse expansion which is so characteristic of those of *P. megarhinus*. They are distinguished from the nasals of *P. paludosus* by less width posteriorly. The nasal notches in *L. laticeps* are narrower and longer than in *P. paludosus*.

Frontals.—The dorsal extent of the frontals is probably the same as in the other allied species. The interorbital portion is much narrower than in *P. paludosus*, and is slightly depressed. From the interorbital region the surface of the frontals rises gradually upward, and is limited externally by the strongly developed diverging temporal ridges which are well marked and are bordered below by the deep temporal fossa. The dorsal portion of the frontals between the converging temporal ridges forms an elongated narrow channel which is bordered upon each side by the convex margins of the temporal ridges. This groove between the temporal ridges becomes shallow at the highest portion of the temporal region, but is continued posteriorly to the junction of the sagittal with the lambdoidal crest. The fusion of the temporal ridges to form the sagittal crest is placed farther anteriorly than in *P. paludosus*, but the crest has not such a wide antero-posterior extent as in the skull of *P. megarhinus*.

Parietals.—The largest part of the parietal is taken up in the formation of the exceedingly deep sagittal crest. The depth of the roof of the brain case, and the consequent reduction of the cerebral cavity, are very great as compared with *P. paludosus*.

Occipitals.—The supra-occipital region of *L. laticeps* is unique in its huge lambdoidal crests which widely overhang the plane of the occiput, and when viewed from the side, extend posteriorly on a line with the posterior limit of the occipital condyles. The lateral margins of the occipital crest are rather different from those of the other allied species, being nearly vertical in position, thus giving to this portion of the occiput a high and narrow form, which is in strong contrast to the very wide posterior and inferior portion. At the union of the sagittal with the lambdoidal crests a broad pyramidal surface is formed; this is curved, its anterior and median part being grooved, thus presenting the commencement of the longitudinal groove of the sagittal crest already described. The lateral expansion of the surface of the lambdoidal crest extends about two-thirds across the surface of the occiput, and then becomes sharp and continuous with the paroccipital region. The constricted portion of the occiput above the foramen magnum is very small in this skull, and diverges behind to form a prominent notch over the foramen. Laterally the paroccipital processes are wide and provided with the usual styliform processes. The transverse extent of the condyles is much less in this species than in *P. paludosus.* The superior and inferior notches are also less, and there is no prolongation of the condylar surface on the basioccipital. The transverse groove upon the surface of the basioccipital between the condyles and paroccipital process is much less marked than in *P. megarhinus.* The posterior prolongation of the base of the occiput beyond the paroccipital region is much reduced in this skull, and consequently the position of the condyles is like that of the Tapir's skull: more underneath and projecting very little behind. The basioccipital is broad and short; its anterior median keel is strongly developed, and the anterior prominences of this portion of the skull are large and well constricted off from the surface of the bone. The lateral surface of the basioccipital is thinner and more deeply excavated than in *P. paludosus.* The lateral vacuities of the basal region of the skull are broad and short and their anterior openings are separated from the posterior by the advancement of the periotic across this cavity. The basisphenoid is short, and its transverse extent between the body and the glenoid facets is considerable. The lamina surrounding the foramen ovale is small and has a much less antero-posterior extent than in the skull of *P. megarhinus.* The antero-posterior and transverse extent of the alisphenoids is much greater than in the Tapir, and this applies as well to other members of this group. The extent of the alisphenoid is shown in the anterior prolongation of the anterior opening of the alisphenoid canal, and its extent superiorly.

Squamosal.—The squamosal forms the largest part of the convex surface of the temporal fossa, as above the squamoso-parietal suture this fossa becomes deeply excavated and forms the base of the perpendicular portion. At the middle of its superior portion the squamosal has two well marked foramina which are apparently absent in the skulls of other species of this subfamily. The zygomatic portion of the squamosal is very broad, heavy, and widely separated from the surface of the skull, thus forming a marked character. With the huge crest already described the skull of this species presents a grotesque appearance. In *L. laticeps* the basal portion of the squamosal differs in extent and position from that of *P. paludosus*; in the latter the glenoid portion is straight and more widely separated from the skull than in *L. laticeps.* The glenoid facet is at right angles to the axis of the skull, whereas in *L. laticeps* it is oblique in position. The auditory processes closely resemble those of *P. paludosus* in form; the postglenoid is shorter, broader and its axis is parallel with that of the glenoid facet. An internal glenoid process is present in *L. laticeps.* The post-tympanics are heavier, stouter and more divergent than in *P. paludosus.* At their basal portion and at their junction with the paroccipitals, there is a large venous foramen present as in the skull of *P. paludosus*. The auditory processes are slightly separated, and the mastoid probably did not appear upon the surface of the skull.

Malar.—The form of the malar insertion of *L. laticeps* closely resembles that of *Telmatotherium*. It arises abruptly from the cheek, its anterior extremity is rounded, and from this portion a prominent lateral keel arises from the surface of the bone, separating the flattened superior surface from the inferior. Posterior to the orbital processes, the malar is round in section and differs in form from that of *P. paludosus*, in which the posterior part of the malar is strongly compressed into a broad lateral plate. The relation of the malar insertion to the infraorbital foramen is different from that of the larger species of *Palæosyops*. In *L. laticeps* this foramen is considerably anterior to the origin of the malar, and is therefore exposed. The anterior border of the malar is above the anterior limit of the first molar and it is thus considerably more prolonged forward than in *P. paludosus*. The dimensions of the palate are nearly the same as in the other allied species, although its roof is more excavated than in the latter. The inferior termination of the palate is opposite the posterior border of the second molar.

Foramina.—The condyloid foramen is very small in *L. laticeps* and is placed nearer the condyle than in *P. paludosus*. The foramen lacerum posterius is separated from the foramen lacerum medium by the prolongation of the periotic across the lateral vacuity. The foramen ovale is small, and nearer the foramen lacerum medium than in *P. paludosus*. The posterior opening of the alisphenoid canal is unusually large, and is placed rather more forward than in the skull of *P. megarhinus*. The pterygoid plate of the sphenoid, forming the external walls of the alisphenoid canal is flat and much elongated from before backward. The extent of the alisphenoid canal has already been referred to in describing the skull of *P. megarhinus* and it seems to be a character of this group of Perissodactyles. The anterior common opening of the alisphenoid canal and the sphenoidal fissure is very large. This canal is not divided by a horizontal septum separating the alisphenoid canal proper from the common canal for the sphenoidal fissure and foramen rotundum as in the skull of the Tapir. At the superior inner border of the anterior opening of the alisphenoid canal is situated another foramen, which may be the optic; if so, it has an extremely posterior position; it is widely separated from the alisphenoid canal, as in the skulls of the Tapir and Rhinoceros. In *Equus*, on the other hand, the optic foramen is placed just above the foramen rotundum and on a line with the inferior limit of the alisphenoid canal.

Cranial cavity.—The encephalic cavity of the skull of *L. laticeps* is much more reduced than in *P. megarhinus*, and the size of its brain cavity indicates that the total bulk of the brain of this animal could not have been more than one-half that of *P. megarhinus*. The antero-posterior extent of the cranial cavity is the same as in the latter species, but the great development of the walls of the brain case of this species is associated with a very small brain.

SKELETON.

Scapula (No. 10,359), Pl. XII, fig. 24.—This scapula is not associated with any other bones of the skeleton, so that its reference to this genus is not certain. I refer it to the genus *Limnohyops* because it is quite different from the scapulæ described as belonging to the two species of *Palæosyops* and is altogether too large to belong to *Hyrachyus*. It may possibly belong to the genus *Telmatotherium*, although it is much smaller and lighter than I should expect to find in that genus. It fits, moreover, a proximal part of a humerus whose form and measurements correspond very closely with those of the type specimen of *L. laticeps* in the Yale College Museum.

The following are the peculiarities of this scapula as compared with that of *P. paludosus* :—1. The form of the glenoid cavity is higher and narrower. 2. The prescapular fossa is much bent inward, and the plate of bone forming it is thin. 3. The spine forms an acute angle with the plane of the glenoid cavity instead of a right angle as in *P. paludosus*. 4. The tuberosity is not separated by a notch from the glenoid border, and the tuberosity differs in shape from that of *P. paludosus* in being more triangular in outline and acute at its distal portion. 5. The internal surface is provided with a well marked vertical ridge, which is wanting in the scapula of *P. paludosus*. 6. The coracoid region is fully as large and heavy as in the larger

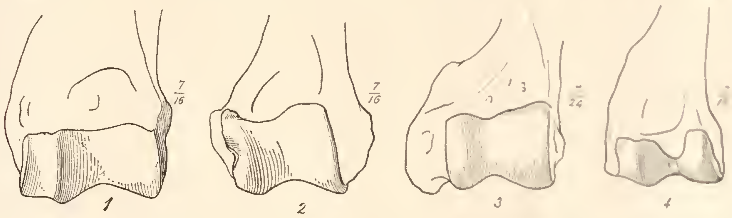


FIGURE 8.—Comparative view of humeral trochleæ. 1. *Tapirus indicus*. 2. *Palæosyops minor*. 3. *Rhinoceros bicornis*. 4. *Palæotherium latum*.

species of *Palæosyops*, being noticeably large in proportion to the size of the scapula. The neck is also more constricted off, and much smaller in this scapula than in *P. paludosus*.

Humerus (Pl. XII, fig. 25).—There are a number of parts of humeri in the collecion which I refer to *L. laticeps*, one in particular, No. 10,367, which fits fairly well the radius and ulna which will be described later as belonging to this species. The humerus shows its primitive character in being much longer than the bones of the lower arm. The shaft is rather long and slender and has heavy distal and proximal portions. The anterior face of the shaft exhibits a prominent ridge, the posterior continuation of the deltoid ridge. The description of the proximal portion of this bone is derived from another specimen, No. 10,367 A. Comparing the proximal extremity of the humerus of *L. laticeps* with that of *Tapirus* we find that its head is not only placed farther posteriorly, but is more strongly turned post-axially. The greater tuberosity has about the same form as in the humerus of the Tapir. It is placed a little higher than the head, but its processes are not as prominent as in the Tapir. The greater tuberosity is provided with a hook-like incurved process. The bicipital groove is long, shallow and shows no signs of division. The lesser tuberosity is smaller than in the humerus of the Tapir, and does not extend as far forward; its anterior extremity is also more pointed. The deltoid ridge is only slightly marked. This part of the shaft is deep from before backward and strongly compressed. The trochlear surface of the humerus is the most characteristic part, and its form and the divisions of the trochleæ are quite different from any that I have examined, although De Blainville's figure of *Palæotherium* indicates that the trochlear surface of the humerus in that genus resembles that of *Limnohyops*. If we compare the distal extremity of the humerus in this species with that of the Tapir (Fig. 8, p. 357), the difference in character is at once apparent. In *L. laticeps* the plane of the internal trochlea is oblique to the axis of the bone and takes up more than half of the articular surface. In the Tapir on the other hand this trochlea is more nearly horizontal, and there is no deep concavity of the face of the humerus separating the two trochleæ. In *L. laticeps* the external trochlear forms nearly a right angle with the internal and is strongly convex and separated medially by a rounded keel The external slope is convex and oblique, tapering to a tongue-shaped superior prolongation. In *Palæotherium* the keel of the external trochlea is not prominent, and in *Hyrachyus* this character of the external slope of the trochlea differs from that of *L. laticeps*. The condyles are more prominent than in the humerus of the Tapir, the internal being large and rough. The supinator ridge is well marked and longer proportionately than that of the Tapir. The anconeal and supra-trochlear fossæ are very deep, but they contain no perforation.

Radius, (No. 10,013). Pl. XII. figs. 26, 27.—This radius, with the ulna associated with it belongs to the same individual as a manus, No. 10,013, all being in the Princeton collection. Corresponding to the close similarity in form between the humeral trochleæ of *Limnohyops* and *Palæotherium*, we find the form of their radii similar. The head of the radius has the same form as in *Palæotherium*. The section of its superior articular surface is oval, the broadest part being internal and corresponding to the half trochlea of the humerus. This trochlea is very oblique, and is separated from the external by a ridge which is bordered anteriorly and posteriorly by prominent processes. The external trochlea of the radius is concave and narrower than the internal. It is narrow externally and bordered by a prominent hook-like process; posteriorly it is excavated deeply by the external radio-ulnar facet. The anterior aspect of the shaft of the radius is convex, its posterior face is divided by a prominent longitudinal ridge for muscular attachment. The upper external border limiting the internal ridge is thin, having a long fossa just within its border. The distal extremity of the radius is heavy, the anterior aspect of the same showing deep grooves for the flexor muscles. The distal articular surface is deep in comparison to its width and is not subdivided by a ridge; its lunar portion is concave, the scaphoid surface being oblique to it, and terminating at the end of the prominent styloid process of the radius. There is no radial cuneiform articulation.

Ulna, No. 10,013.—The ulna corresponding with the above radius is a long and slender bone. The olecranon tapers gradually from its base to the apex which is expanded, flattened and strongly compressed laterally, forming a rather thin plate which separates the expanded distal portion from the base. The sigmoid cavity is deep and overhung by the prominent coronoid process. The distal part of the sigmoid cavity is wide, being limited at each side by prominent processes. In front of the sigmoid cavity the shaft has a deep fossa limited below by an oblique ridge running across the radial surface of the bone. The shaft of the ulna is triangular in section, with its internal side concave, its radial face being oblique to the latter, and separated from the internal side by a prominent angular ridge. The

MEASUREMENTS OF THE APPENDICULAR SKELETON.

		P. paludosus.	P. minor.	P. longirostris.	L. laticeps.
		M.	M.	M.	M.
Scapula	breadth of neck	·083	·060	– –	·067
	length of glenoid	·061	·053	– –	·058
	length coracoid	·026	·018	– –	·020
Humerus	length	– –	– –	– –	·300
	distal breadth	·088	– –	– –	·080
	outer trochlea	·033	– –	– –	·021
	inner trochlea	·038	– –	– –	·030
Radius	length	– –	– –	·233	·255
	prox. surface transverse	– –	– –	·048	·052
	dist. surface transverse	·062	– –	·049	·045
Ulna	total length	– –	– –	·283	·308
Femur	total length	·380	·325	– –	·358
	prox. sur. transverse	·120	·098	– –	·108
	dist. sur. transverse	·090	·072	– –	·076
	breadth of shaft at 3rd trochanter	·080	·068	– –	·065
Tibia	total length	·320	·277	– –	– –
	prox. sur. transverse	·088	·078	– –	– –
	dist. sur. transverse	·068	·048	– –	– –

distal part of the radial face is twisted upon the axis of the bone, so that this portion of the face does not correspond with the upper part. As a result of this rotation of the distal extremity backward, the articulation of the ulna with the carpus is very different from that of the Tapir. Viewed from the front we observe in the manus of *L. laticeps* that the distal extremity of the ulna is placed far to the side and backward; consequently the pisiform is shut out from forming a portion of the anterior face of the carpus, this being largely due to the shape of the cuneiform, which is rectangular instead of being triangular as in the Tapir.

The ulnæ-cuneiform facet is half crescentoid in form and bordered externally by the vertical facet for the pisiform.

Manus, (No. 10,013), Pl. XIV, fig. 39.—This is one of the most beautifully preserved specimens in the collection, and the condition of its facets is fully as good for osteological purposes as in recent animals. I have referred this manus to the genus *Limnohyops* as, after carefully studying some remains of the manus of *L. laticeps* in the New Haven Museum, I find that its characters closely correspond with those of the latter, although the measurements of the metacarpus are considerably less in this specimen than those of Marsh's type and may represent a different species. The hand of this species as compared with that of *P. paludosus* is very much lighter in construction, and its general proportions approach more nearly those of the Tapir.

Carpus.—The carpus is somewhat broader in proportion to its height than that of the Tapir, and the general relations of the carpal elements are quite different. The following are its main peculiarities:—1. Great extension posteriorly of the lunar between the magnum and unciform. 2. Separation of the magnum from the unciform anteriorly. 3. Position of the lunar-magnum facet, it being nearly vertically placed. 4. The large contact between the unciform and metacarpal III. 5. A point to be observed in this carpus is that it approaches more nearly the mesaxonic type than that of *P. paludosus*; this arises from the fact that the unciform-metacarpal III articulation is greater than in *P. paludosus*, and consequently metacarpal III approaches more nearly the mesaxial line of the hand than in the latter form. In the Tapir we see a more advanced stage of Mesaxonia where the metacarpal III is very much larger than the other metapodials, and the axis of the manus divides this metacarpal equally.

Scaphoid.—The proportions of the scaphoid are rather high and narrow, and approach those of the same bone in the carpus of the Tapir. The superior face is flat, broad transversely, and posteriorly limited by a deep fossa which penetrates about one-half the vertical height of the bone. The scapho-magnum facet is rather obliquely placed, as in *P. paludosus*; it covers the whole superior surface of the magnum; the posterior portion articulating with the pivot of the magnum is tongue-shaped, and its anterior portion forms an acute angle with the part of the facet more anteriorly placed. In *P. paludosus* the posterior portion of this facet is broad and short, and thus differs very much in form from that of *L. laticeps*. The scapho-trapezoid facet is separated from the posterior part of the facet for the magnum by a deep pit. It is deeply concave from side to side and is continuous at its posterior part with the scapho-trapezium facet, which is well marked in this specimen, and forms quite a broad vertical facet for the trapezium.

Lunar.—The lunar is the most characteristic bone in the carpus of *L. laticeps*, and by its slender proportion and the position of its distal facets can be at once distinguished from the lunar of *P. paludosus*. The vertical axis of this bone is much greater than its transverse, and from before backward it is not as deep as in the lunar of allied species. The superior face is convex from before backward, and is separated from the posterior by a slight depression externally. A deep vertical fossa borders the facet above. The lunar-scaphoid facets are long and narrow, the upper one being deeply concave, the lower more nearly plane and continuous with the lunar-magnum facet. The facets of the inferior face of the lunar are very characteristic of this species. The whole of the lower part of the inferior face is prolonged into a beak-like process which penetrates posteriorly nearly to the distal face of the carpus, and thus the magnum and unciform appear to be nearly separated from each other upon viewing the carpus anteriorly. The posterior prolongation of the lunar is not subdivided equally, its ulnar side being much larger than its radial. The lunar-magnum facet is nearly vertical in position, its postero-superior part curving upward and backward to become continuous with the lunar-scaphoid facet, which, at its posterior part, is very narrow and nearly shut off from the posterior facet for the pivot of the magnum. The facet on the lunar for the pivot of the magnum is much more nearly vertical in position than in *P. paludosus*, and not as concave. The lunar-unciform facet is large and deeply concave; the anterior part of the lunar bordering on this facet is very oblique in position running downward and inward to meet the lunar-magnum facet and form the beak of the lunar. In comparing the carpus of *Limnohyops laticeps* with that of other forms I can find no Perissodactyle in which the lunar is so widely prolonged between the elements of the distal row as in this genus. In *Hyrachyus* the lunar-magnum facet is lateral in position and more vertically placed than in *L. laticeps*, but nevertheless its distal extremity is not prolonged as in this species. *Isectolophus* shows a prolongation of the lunar distally, but in that genus the two distal facets of this bone are more nearly equal, and have about the same angle of inclination to each other. In *Tapirus* and *Palæotherium* the lunar does not cross the middle plane of the carpus (at least in *P. medium*, see De Blainville). *Titanotherium* approaches *P. paludosus* more nearly in the form of its lunar, its lunar-magnum and unciform relations being about the same. There are a number of other lunars in the collection which belong to a form closely allied to *L. laticeps*, but as they are not associated with any other bones of the skeleton I cannot identify them with certainty. In these lunars the proportions in the size of the lunar-magnum facets undergo great variation. In the most extreme form, No. 6, this facet is nearly vertical, whereas in No. 5 it is more oblique and very much reduced in size.

Cuneiform.—The cuneiform of *L. laticeps* has about the same shape as that of *P. paludosus*, although rather more compressed. Its ulnar face is slightly concave and the cuneiform-pisiform facet is long and narrow. Its unciform face is rather broad, and more concave than in *P. paludosus*.

Pisiform.—The pisiform is unusually well preserved in this carpus; its form is long and compressed, its distal extremity being rough and compressed from side to side. The neck of the pisiform constricts the tuber from the articular surface which presents a narrow facet for the cuneiform. The pisiform-ulnar facet is triangular in outline and forms an angle with the lower facet. Comparing the pisiform of this species with that of the Tapir we see a great similarity in their form, the latter having the same long and compressed shape as in that of *L. laticeps*.

Trapezium.—The trapezium is an oval pear-shaped bone, quite thick proximally and tapering distally to a pointed extremity; it shows two well developed facets for the scaphoid and trapezoid. Its contact with metacarpal II is small.

Trapezoid.—The trapezoid is higher and narrower comparatively than in *P. paludosus*. It is deep from before backward as in the latter species, and has the same arrangement of its facets.

Magnum.—The magnum of *L. laticeps* is quadrangular in outline, and differs in form from that of *P. paludosus* in which this bone is broader and shows at least five sides. The superior face of the magnum is nearly horizontal in front; posteriorly, this face is provided with a prominent ridge, dividing the two oblique facets of the magnum for the scaphoid and lunar respectively. The facet for the latter bone is more oblique than that for the former, corresponding in position to the vertical lunar-

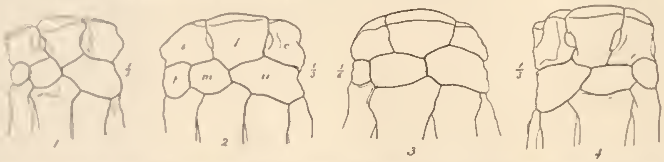


Figure 9.—Morphology of the carpus. 1. *Limnohyops laticeps*. 2. *Palæosyops paludosus*. 3. *Titanotherium* (sp. indet.). 4. *Tapirus indicus*.

magnum facet. The external side of the magnum is nearly all taken up by the lunar, the unciform having only a very slight contact anteriorly, but the magnum-unciform facet arises vertically upon the magnum posteriorly, thus offering a larger contact between the magnum and unciform posteriorly than anteriorly. The inferior facet of the magnum is deeply concave from before backward, and is limited behind by the descending process of the bone. The position of the magnum upon metacarpal III is more oblique than in *P. paludosus*, and this condition arises from the large process developed by metacarpal III for articulation with the unciform.

Unciform—The shape of the unciform is nearly identical with that of *P. paludosus* and is not at all Tapiroid in outline; its transverse axis is much greater than its vertical, although the posterior face is rather more oblique and approaches more nearly the vertical than in *P. paludosus*. Its cuneiform surface is oblique and strongly convex from before backward. A shallow fossa placed upon the tuberosity of the bone limits this facet posteriorly. The tuberosity is large, laterally placed, and diverges outward. The unciform-lunar facet is large, and forms a right angle with its superior facet, the former is slightly concave in front, becoming convex posteriorly, and presenting a ridge separating it from the facet above. The unciform-magnum facet is placed upon the inferior face of the bone. It is triangular in outline, the apex being placed anteriorly and offering only a slight articulation for the magnum. The other inferior facets of the unciform are as in *P. paludosus,* although the unciform-metacarpal III facet is larger proportionately than in that species. The facet for metacarpal V is large, taking up about one-third of the inferior surface of the bone.

Metacarpals.—The metapodials in *Lymnohyops laticeps* are rather long and slender, and their shafts are almost straight. The metacarpal region is more compact, and the digits do not diverge from each other as much as in *P. paludosus.* The shape of the proximal part of metacarpal II is quite characteristic; it enlarges gradually as it approaches the articulating surface of the bone, its internal border being rough for muscular attachment. The external border sends up an ascending process for articulation with the magnum and metacarpal III. The superior facet of this metacarpal is triangular in form, its external border being very oblique, and forming with the internal the apex of the triangle. The metacarpal II-magnum facet is long and narrow; it is very oblique in position from before backward, and inclined from the vertical from above downward. The metacarpal II–metacarpal III facet is confined to the anterior part of the bone, it is situated under the anterior half of the facet just described, and is tongue-shaped in outline, the larger part being in front. Upon its radial side this metacarpal exhibits a small flat facet for the trapezium. The form of metacarpal III is characteristic of *L. laticeps.* It is long, straight and slender, its distal portion being slightly enlarged, and provided as in the other metapodials with a prominent keel. The third metacarpal does not show as much disproportion in size to the fourth in *L. laticeps* as we see in the manus of the Tapir. In the latter the metacarpal III transmits a larger proportion of the weight than in *Limnohyops.* The superior facet of metacarpal III for the magnum is narrow from side to side, but very deep from before backward; its anterior portion is slightly convex, the posterior half of the facet being inclined downward and terminating in a triangular point. On the radial side this metacarpal shows a small and anteriorly placed facet for metacarpal II. The ulnar side of the third metacarpal exhibits a large process, the form of which is square, with a large, flat and oblique surface for articulation with the unciform. The metacarpal III–unciform facet is very large compared with the size of this metacarpal, comparatively much larger than in the Tapir or Rhinoceros. Below the latter facet this metacarpal shows two large oval facets for metacarpal IV. They are not continuous, and are widely overhung by the process above described. The relation of metacarpal III to the magnum and unciform is different from that of the Tapir's carpus. Owing to the separation anteriorly of the two latter carpal elements in *L. laticeps* a greater proportion of the unciform transmits its weight to the median digit, whereas in the Tapir a larger proportion of this weight is transmitted through the unciform to the metacarpal IV. Metacarpal IV like that of the Tapir is slightly curved toward the ulnar side of the carpus, but differs from the latter in approaching more nearly the size of metacarpal III than in the Tapir. The proximal portion of this metacarpal is rather large in proportion to the diameter of the shaft; its unciform facet is quadrangular in form, being very deep, narrow and convex from before backward; it is also slightly concave from side to side. The facets for metacarpal III are oval in outline, the anterior one being oblique to the unciform facet; the posterior is vertical in position and larger than the anterior. Upon its ulnar side metacarpal IV shows two elongated facets for metacarpal V; these are curved slightly. Beneath both the radial and ulnar facets of this metacarpal are shallow and rough fossae. The fifth metacarpal does not differ as much in size from metacarpal II as in the Tapir, and there is not such a striking difference in the length of its shaft as compared with metacarpal IV, as in the carpus of the Tapir. Its proximal end is very much enlarged, showing an upward-curved rough tuberosity which terminates in a vertical process bordering upon the superior surface. Externally the facet for the unciform is convex from before backward, concave from side to side, and is bordered externally by the process above described. The facets on metacarpal V for metacarpal IV are narrow and continuous. The distal part of the former metapodial is quite heavy, the middle part of its shaft being very slender proportionately. The proximal and middle phalanges of the digits are rather broad and short. The ungual phalanges are short and wide distally. Their distal margin is interrupted at its middle point by a deep incision, which is bordered upon each side by a deep pit. This incision of the ungual phalanges is said to be wanting in the manus of *Hyrachyus*.

Femur, No. 10,292 and No. 10,351.—There are two femora in the Princeton collection whose form is more elongated than those of *P. minor*. They are intermediate in this respect between the latter species and *P. paludosus*. The proximal and distal extremities of these femora closely approximate in their characters those of the smaller species of *Palæosyops*, these portions being much smaller than in the femur of *P. paludosus*. Compared with proportionate measurements of the anterior extremity of *L. laticeps*, I find that these femora correspond with them very well, so I shall provisionally place them under *L. laticeps*. Their long and narrow shafts are strikingly characteristic and distinguish them sharply from those of *P. minor*. In form, their third trochanter is broader and more elongate than that of *P. minor*, and this portion of the shaft transversely is much less in extent than in the latter species. The neck is more pronounced than in *P. minor*, and the triangular raised portion of the shaft below the head is narrower and longer. The trochlear surface for the patella is more elongated, while the antero-posterior diameter of the distal extremities is greater than in the femur of *P. minor*. The intercondylar fossa is deep. The posterior face of the shaft is very flat, and below there is an indication of a slight fossa for the flexor perforatus muscle.

Tarsus, (Pl. XIV, fig. 41).—The foot which I refer to this species was associated with a proximal portion of a metacarpal III, whose form and dimensions correspond almost exactly with those of manus No. 10,013 which has already been referred to *L. laticeps*, so that I shall describe this tarsus as belonging to this species. The form of the pes is long and narrow; its length corresponds almost exactly with that of the Indian Tapir, but it is narrower. Compared with the foot of *P. minor* we see considerable difference in size, as the pes in that species is much broader and heavier than in *L. laticeps*. The metapodials are much lighter than in *P. minor*, and closely resemble in their proportions those of the Tapir. The middle metatarsal is considerably larger than the lateral metapodials, in this character also approaching the foot of the Tapir.

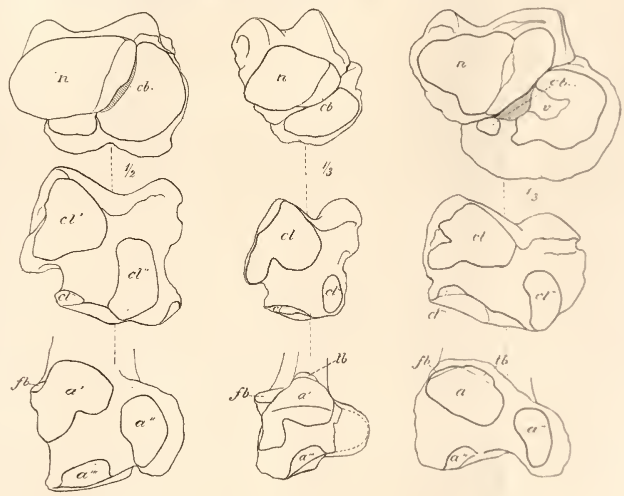


FIGURE 10.—The astragalar and calcaneal facets in the *Palæosyops–Titanotherium* series. *Palæosyops paludosus*, Princeton collection; *Diplacodon ? elatus*, Princeton collection; *Titanotherium* (sp. indet.), Princeton collection, after Osborn.

Calcaneum.—The calcaneum of *L. laticeps* is long and narrow, with a much compressed tuberosity which has a concavity at the extremity subdividing this portion of the bone and resembling in form that of the calcaneum of *Hyracodon*. The neck of the calcaneum is deep, and where it joins the articular portion, it is compressed and continued into the narrow anterior part. The articular surface is narrow and deep, especially so in this species. The ectal facet is broad transversely, and the anterior prolongation is not so conspicuous as in *Palæosyops paludosus*. The sustentaculum is very long and narrow and is placed close to the ectal facet. The distal portion of both calcanea which I refer to this species are damaged, so that it is impossible to say whether the sustentacular facet is continuous with the inferior or not. I think it probable that they are continuous, as another calcaneum closely allied to the one under consideration shows both these facets in continuity. The inferior facet is rather large and its posterior extension considerable; its plane forms a right angle with that of the cuboid facet. The latter is narrow and deep from above downward; its surface is concave, and only the upper part of its internal border is truncated by the inferior facet. In *L. laticeps* the lower border of the cuboid facet is narrow and round; in the other related forms it is flat. A fibulo-calcaneum facet is not well marked.

Astragalus.—The form of the astragalus closely resembles that of *P. minor;* it is long and narrow with its distal portion well constricted off. The trochlear surface is shallow. The facets of the inferior surface are large, the sustentaculum and inferior being continuous. The ectal facet is not as deep as in *P. minor*, but it has the same general form. The sustentaculum is long and narrow and its plane is not as oblique as in the smaller species of *Palæosyops*. The distal continuity of the sustentaculum with the cuboid facet is not interrupted by a ridge as in *P. minor*. The inferior facet reaches about half way across the anterior border of the bone, before coalescing with the sustentaculum. The cuboidal facet is long and narrower than in *P. minor;* its plane is nearly parallel with the navicular face of the astragalus, thus differing widely from that of *P. minor* where the cuboid facet forms a sharp angle with the anterior face of the bone. The form of the navicular facet is not so strongly triangular in outline and is more elongated transversely than in *P. minor*. The more horizontal position of the sustentacular facet produces only a slight angle on the internal border of this face. The characters given above for the astragalus of *L. laticeps* approach closely those found in the larger species of *Hyrachyus*, but its large size excludes it from that genus.

Cuneiforms.—The ectocuneiform is wanting in this pes; it is probably much higher and narrower than in *P. paludosus*, and approaches more nearly the diameter of this bone in *Hyrachyus*. The mesocuneiform is preserved; it is a very deep bone with a small anterior face; its articular surfaces are concave antero-posteriorly.

Cuboid.—The cuboid is still another tarsal bone of this species very closely resembling that of *Hyrachyus*, although it is rather more rectangular and shorter than in that genus. Its external border is straight and not concave as in *Hyrachyus*. The tuberosity of the cuboid is wanting in this specimen, but its position was probably very similar to that of *Hyrachyus*. The astragalar facet is large and is not separated from the plane of the calcaneal facet as in *P. minor*. The facets for the navicular and ectocuneiform extend more than half across the internal face of the bone; they are separated by a ridge, and the posterior part of the navicular facet extends vertically across the posterior internal border of the bone. The distal articular face of the cuboid is slightly concave, and is much smaller than in *P. minor*. The upper surface of the cuboid in *Hyrachyus princeps* is excavated; in this species, on the contrary this surface is perfectly flat; the distal face of the cuboid in the former species has a straight internal border, whereas in *L. laticeps* this border is round.

Metatarsals.—The metatarsals agree in many of their characters with those of *Hyrachyus*, but they differ from them in being longer and broader than any metapodials in the collection which pertain to the larger species of *Hyrachyus*. In *Hyrachyus*, metatarsal III is considerably larger than the lateral metapodials, and this character distinguishes it from that of *Palæosyops* while it agrees with that of *Limnohyops*. A long metatarsal III, which probably belongs to a large species of *Hyrachyus*, has its shaft much smaller and straighter than in *L. laticeps*; its distal articular surface is also much less, so we may believe that the larger species of *Hyrachyus* approached *L. laticeps* very closely in height but that the extremities were more slender. Other remains in the collection pertaining to a large species of *Hyrachyus* support this view. The proximal portion of the second metatarsal has nearly the same form as in *Hyrachyus*. Its external border slopes gradually downward, and was not so abruptly cut off as in *P. minor*. It agrees with that of *Hyrachyus* in having a facet for the entocuneiform. In the species of *Palæosyops* examined the second metatarsal shows no entocuneiform facet. The superior facets of this metatarsal are elongated and concave. The facets on metatarsal II for the ectocuneiform are round and widely separated, and the anterior facet is supported upon a constricted neck. The shaft of metatarsal II is slender and bent inward, its anterior surface being rounded, with a flattened posterior portion; its distal articular surface is slender with a keel which is not prominent. Metatarsal III is the most characteristic metapodial of this region and its articulation with the fourth is quite different in character from that observed in allied species. The articulations between metatarsals III and IV in *Hyrachyus* and *Palæosyops* are much flatter than in *Limnohyops*, and there is no prominent prolongation of the external face of these metapodials. In *L. laticeps*, on the contrary, the anterior external angle of metatarsal III forms a strongly incurved hook-like process; this is bordered posteriorly by a vertical facet which is oblique above and concave below. Upon viewing metatarsal III from the front the process above described becomes prominent, and its irregular curved border terminates above in this prominent process. The ectocuneiform facet of metatarsal III is more concave, and more raised toward the external side than in *Hyrachyus*; its distal extremity is narrow and straight.

Metatarsal IV is more slender and elongate than the corresponding bone of *P. minor*; its surface for the cuboid is nearly plane. Internally and anteriorly it exhibits a long narrow facet whose surface is strongly convex; this articulates with the peculiar hook-shaped process of metatarsal III, forming a close interlocking articulation. The distal articular surface of metatarsal IV is narrow, the keel of this metapodial being very prominent and bordered externally by a deep notch. A strong contrast to the allied forms is the narrowness of the distal ends of the metapodials of this species as compared with those of *P. minor*. In another portion of a pes belonging to a form closely allied to *L. laticeps* but not identified with it, the cuboid is larger, squarer and offers a larger contact for the astragalus. The sustentaculum and inferior facets of the calcaneum also are continuous. Metatarsal III in this pes shows the same interlocking with metatarsal IV as in that already described, but not quite so well developed. There is a large contaet between the cuboid and metatarsal III.

MEASUREMENTS OF MANUS AND PES.

	P. paludosus.	P. minor.	L. laticeps.
	M.	M.	M.
Total length of manus	·220	– –	·195
Breadth of carpus at middle	·077	– –	·060
Vertical height of carpus	·045	– –	·038
Transverse extent of facets of proximal row	– –		
superior surface	·089	– –	·064
Inferior "	·075	– –	·055
Transverse extent of lunar	·034	– –	·027
Vertical height of lunar	·036	– –	·032
Trans. ext. of lunar-magnum facet	·014	– –	·010
Trans. ext. of lunar-unciform facet	·022	– –	·016
Vertical height of magnum	·020	– –	·017
Trans. ext. of unciform	·048	– –	·039
Trans. ext. of mc. III-unciform facet	·014	– –	·013
Length of tarsus	·126	·120	·122
Breadth of tarsus at middle	·068	·060	·058
Length of sustentacular facet of calcaneum	·032	·030	·028
Length of inferior facet of calcaneum	·015	·020	·017
Breadth of astragalo-cuboid facet	·013	·011	·009
Length of astragalo-cuboid facet	·043	·028	·027
Breadth of astragalo-navicular facet	·031	·023	·021
Breadth of proximal facets of metatarsals	·064	·058	·050

LIMNOHYOPS FONTINALIS.

This small species of *Limnohyops* has been established by Prof. Cope[1] upon portions of a skull which contain the right maxillary bone with all the true molars. The right temporal region of the skull is also well preserved. The left nasal of one side is present. The distinctiveness of the sutures and the porous condition of the cranial roof show that this skull must have belonged to a young individual. In size *L. fontinalis* differs widely from *L. laticeps*, being only about one-third as large as the latter species.

Dentition.—Only the true molars of the right side are preserved in this specimen; the second superior molar is in as fine a state of preservation but it has not been well cleared from the matrix. The molars are very interesting as they show certain relations to *Telmatotherium* corresponding to those of the larger species

[1] Paleontological Bulletin, No. 11, p. 1, Jan. 31st, 1873.

of the genus. A striking peculiarity of the first molar is its extremely small size as compared with molar 2; there is nearly as great a difference between the transverse diameters of the first two true molars as there is between premolar 4 and molar 1 of *P. paludosus*, the latter species showing the difference in size of these two teeth more than any other species of the genus. Another interesting character of the first molar in *L. fontinalis* is that the primitive triangle is more strongly expressed than in any true molar that I have examined in the entire series of species. The protocone of molar 1 is very large as compared with the hypocone and is placed further to the inside than the latter. The hypocone is small and placed far to the posterior internal angle of the molar, and the whole tooth seems to have been in a transition state of development, being in a condition between a premolar and a true molar. In the latter the internal cones are of the same size. The second superior molar has quite a high crown with flat and broad external lobes; the anterior buttress is prolonged, but the median buttress is low and strongly constricted off. With the exception of the large size of the anterior buttress the structure of molar 2 shows close affinity in form to that of *Telmatotherium*. The external lobes of molar 2 have no cingulum, and the V's are divided by a faint median rib. The internal cones are subequal in size but do not show the great difference observed in the first molar. A well marked protoconule is present on molar 2. Both the internal cones of the last superior molar are well preserved and of the same height, thus distinguishing this species from *L. laticeps* in which there is a great difference in the size of the internal cones of the last superior molar. The slight development of transverse ridges on the molars of *L. laticeps* is wanting in this species. The surface of the enamel on the molars of *L. fontinalis* shows a slight tendency to wrinkling, but the teeth are not the least worn.

Summary.—With the exception of the difference in size between molars 1 and 2, I consider that the dentition of this species shows an advance over that of *L. laticeps*. This is proven in the Telmatotheroid characters of its molars and also by the fact that the internal cones of the last superior molar are equal in height; moreover the hypocone of this molar does not exhibit the undifferentiated condition that is found in *L. laticeps* and in some of the transition forms between *Limnohyops* and *Palæosyops*.

Skull.—The skull of *L. fontinalis* closely resembles in form that of *L. laticeps*, especially the occipital region. The antero-posterior axis of the skull is considerably extended and the cranium proper is exceedingly broad and depressed. The dorsal contour of the skull is nearly the exact counterpart of that of *L. laticeps*, although the sagittal region is slightly concave instead of convex as in the latter species. The occipital crest, as in the larger species, is strongly developed for such a small animal, and it widely overhangs the supraoccipital region. The cranial region is elongate compared with that of the facial portion, the latter being abbreviated.

Nasals.—The nasals are broad and short; their superior surface is flat and distally they do not expand. The lateral portion of the nasals is strongly arched downward and their free lateral border is thickened and rounded. At the median nasal suture the bones become very much thinned out. The posterior extent of the nasals is limited and the naso-frontal suture is just behind the posterior limit of the nasal notch. A portion of the frontals of this specimen is preserved, with the median suture very plainly marked, which shows that the frontal region between the orbits must have been flat. The malar insertion rises gradually from the cheek and diverges strongly posteriorly; its superior and inferior borders are convex, the former exhibiting a small orbital process which is turned inward. The orbit is large and its floor is much elongated, with a considerable breadth. The zygomatic arch is long, slender, and does not diverge widely from the skull. The malar part of this arch is compressed from side to side and the zygomatic portion proper exhibits a narrow external face. The temporal fossa is much elongated, the squamosal portion being depressed and broad. The anterior temporal ridges bordering this fossa above are not strongly expressed, and posteriorly they scarcely unite to form a sagittal crest.

Measurements of the Skull of L. fontinalis.

		M.
Length of skull from occiput to end of nasals		·260
Length of temporal fossa		·130
Height of temporal fossa at middle		·045
Breadth of skull above postglenoids.		·106
Length from occiput to base of postglenoid		·062
Length of true molar series		·063
Sup. molar I	ant.-post.	·020
	trans.	·022
Sup. molar II	ant.-post.	·026
	trans.	·027

Parietals.—The parietals and squamosals take about equal share in the formation of the deeply excavated temporal fossa. A peculiarity in this species is the extent of the temporal fossa behind the post-glenoid. The inferior lateral temporal ridges are strongly developed and become continuous with the large lambdoidal crest. The posterior part of the temporal fossa is formed by the anterior prolongation of the broad plates of the supraoccipitals. The large share the occipitals take in the formation of the temporal fossa is unique in this species. Prof. Cope describes this portion of the skull very well when he says "the occipital bone sends a long process forward on the median line forming a half gomphosial articulation with the parietals. The lateral suture of the two bones is considerably in advance of the posterior lateral crest." The postglenoid process in *L. fontinalis* is delicate in form, slender, and tapers forward. It is widely separated from the post-tympanics, much more so than in the larger species of this subfamily. There is a small internal glenoid process in this skull. The union of the post-tympanics and paroccipitals form a short and thick process. There is a narrow strip of bone exposed just behind the post-tympanics, which I take to be a mastoid exposure. A large exposure of the mastoid may also be inferred from the wide separation of the auditory processes. There is no foramen present at the junction of the mastoid with the exoccipitals. The petrous bone is preserved and is situated deeply in the recess between the glenoid and post-tympanics; it is placed on a line with the glenoid cavity and not as far removed from the foramen ovale as is usually the case in the larger species. The foramen ovale, although filled with matrix, is plainly to be seen; it is situated on a line with the internal edge of the glenoid facet.

Relationship and Descent.

In treating of the relationship and evolution of the genera and species in this subfamily, I propose to confine myself to those forms which I have investigated as thoroughly as the present known material will allow. It appears to me that the relationship of some of the Wind River forms to those from the Bridger proper is rather uncertain, although I consider that in *Palæosyops borealis* we have a direct forerunner of the Bridger species of this genus. *Lambdotherium* is the earliest member of this group and it appears that it may have been the ancestor of the whole line. The details of the molars in *Lambdotherium*, and especially of its premolars, depart considerably from those of *P. borealis* and in fact the latter species is much more closely related to *Palæosyops* and *Telmatotherium*, than to *Lambdotherium*. At any rate it is probable that in an earlier formation than the Wind River Eocene, a common form gave origin to the genera *Lambdotherium* and *Palæosyops* and I am inclined to believe that the former genus may be a side line, not leading directly to *Palæosyops* as supposed by Cope, and that the latter genus has not branched off from *Lambdotherium* in Middle Eocene times. This view is supported by the fact that I have lately discovered material in the Princeton collection from the bottom of the Eocene, namely the Wasatch, which is referable to *Lambdotherium*[1] I have found it rather difficult to decide which of the two genera, *Palæosyops* or *Limnohyops*, is the most primitive in its dentition, although after considering all their characters and having compared them with more primitive types, I believe that *Limnohyops* is more primitive in its dental structures than *Palæosyops*, although in some of the characters of its appendicular skeleton, the former genus is more specialized than the latter. There is no question as to the phylogenetic position of the genus *Telmatotherium* in the series. It certainly is the most specialized genus of the group and represents the direct ancestor in the Bridger of the more highly specialized genus *Diplacodon*. In describing the evolutionary stages of the species of the *Palæosyopinæ*, I propose to take up the characters of the skeleton as they have been described in the osteological part of this memoir.

Dentition.—In *Limnohyops laticeps* the crowns of the molars are low, and there is no constriction of the external V's by a median buttress as in *Telmatotherium*. A

[1]This specimen is a portion of a mandible including teeth, which Dr. W. B. Scott informed me is from the Wasatch.

decided character of this form and one which occurs in no other species of the group is the presence on the two anterior upper true molars of well developed intermediate conules while there are traces of transverse ridges connecting the external V's with the internal cones. In such primitive genera as *Phenacodus* and *Hyracotherium* the last superior molar is provided with two internal cones, and I conclude that this character being found in *Limnohyops* is more primitive than in the genus *Palæosyops*, where the hypocone of molar 3 has degenerated; this is a specialization in the latter genus, which holds good for the genera *Telmatotherium* and *Diplacodon*. The retention of the protoconule on the last superior premolar of *L. laticeps* indicates its primitive character while the anterior external median rib is also prominent. The fact that in *L. laticeps* the external lobes of the last superior premolar are subequal may be regarded as a specialized rather than as a primitive character. I consider *Limnohyops fontinalis* as quite a highly specialized member of the genus because the metaconules of the true molars have been lost, and the crowns of the molars are comparatively much higher than in the less specialized species of the genus, while the external V's in *L. fontinalis* are wider, and in some respects have taken on a more strongly Telmatotheroid facies. The greater size of the protocone of molar 1 in *L. fontinalis* as compared with the hypocone is a primitive character, the hypocone appearing as if it had been just added.

I regard *Palæosyops paludosus* as decidedly the most primitive member of the genus in its dental characters, and it is particularly fortunate that such is the case as the material referable to this species in the Princeton collection is the most abundant, so that I am enabled to point out the central form, as it were, of this species, and to indicate a number of interesting transitional varieties which are grouped around it and have characters pointing toward *Limnohyops* and *Telmatotherium* respectively. These varieties of *P. paludosus* illustrate how closely the genera are bound together by transitional forms. In typical *P. paludosus* the incisors are of a conical form without the basal cingula which is so characteristic of these teeth in *Telmatotherium*. The canines are large, conical, round in section, and are not provided with strong cutting ridges. The upper and lower molar series of *P. paludosus* have very low and undifferentiated crowns. The superior premolar 1 is a cone without the anterior and posterior heels present in *Telmatotherium*. The crowns of all the superior premolars are low and their external lobes are equal; only in the last superior premolars are the external lobes separated by a buttress, and this appears to be a specialized character of *P. paludosus*, as in *Lambdotherium* there is no separation of these lobes. There is only a very slight indication of protoconules on the premolars of *P. paludosus*. The last premolar is much smaller transversely than the first true molar, which is a primitive character, these teeth in the more specialized *Telmatotherium* being more nearly equal in transverse extent.

The first lower premolar of *P. paludosus* is a simpler tooth and much smaller than in *Telmatotherium*, the following inferior premolars being less specialized than in the latter genus; that is to say, the second has its protoconid much smaller and the fourth has its V's less well developed. In *P. paludosus*, as in all the other species, the inferior premolar 2 appears to be less highly developed than in the genus *Lambdotherium*, where in some species a well marked rudimentary metaconid is present on premolar 2. The crowns of the superior true molars of *P. paludosus* are very brachydont and the external V's are much rounder and narrower than in *Telmatotherium*, while the external face of the molars is totally without a cingulum. A primitive character of the upper molar series of *P. paludosus* is the presence of a large anterior intermediate conule on each true molar. The protoconules are well developed in *P. paludosus* and gradually become rudimentary in some of the smaller species of *Telmatotherium*. In the most primitive upper molar of *P. paludosus* in the collection (10,009 A), the external V's are narrow and each one is provided with a prominent vertical rib, which I take to be the remains of the convex external surface of the bunodont cone from which, by the coalescence of the latter, the external V's of this type of molar have been derived. The median buttress in this molar is very low and undeveloped. Another primitive character of the tooth is the presence of both the intermediate conules, the anterior being connected by a well marked ridge with the anterior cingulum. The inferior molars of *P. paludosus* have their V's much lower and their crests less well developed than in *Telmatotherium*. There are no traces of any posterior intermediate conules on the inferior molars 1 and 2 of this species.

I believe the last inferior molar of *P. paludosus* has its posterior tubercle highly specialized because in the supposed ancestor of *Palæosyops* (*Lambdotherium*) the posterior tubercle of molar 3 is an open lobe and not a cone. This is also the case in a less specialized form like *Hyracotherium*, where the bunodont character of the lower molars is strongly preserved. In the latter genus the posterior tubercle is less specialized than in *Lambdotherium*. It consists merely of an open semicircle with its arms running to the external and internal face of the molar. In *Lambdotherium*, on the other hand, this tubercle has assumed a more specialized character; it has become more constricted off from the body of the tooth by the external crest of the tubercle becoming no longer continuous with the external border of the tooth, and by running inward its internal crest has become continuous with the entoconid. In most of the posterior and inferior molars of the species of this subfamily such is the condition of this tubercle, but in *P. paludosus* and some of its varieties the crests and valleys have become aborted and the original open and functional lobe has degenerated to a mere cone.

The first variety of *P. paludosus* which I shall describe is a portion of a skull, No. 10,276, from the Bridger proper, in the Princeton collection. It contains a part of the molar series, and on one side the last two upper molars. The total dimensions of these teeth are considerably less than in the typical form; their enamel is smooth with reduced intermediate tubercles. A very interesting feature in the last molar of this skull is that its posterior internal cingulum has fused with a small posterior cone thus forming a rudimentary hypocone. More accurately speaking it is probable that this hypocone is in a state of degeneration. If this view is correct I would regard the variety as being placed lower in the scale of evolution than the typical *P. paludosus*, and forming a transitional stage between the latter species and *L. laticeps*. Prof. Cope[1] figures a set of superior molars of *P. paludosus* which has very interesting transitional characters. In this series the last molar has a rudimentary hypocone, but the crowns of the premolars are higher than in the typical form. The last tooth of this series is not separated by a median buttress as is generally the case in *P. paludosus*, while the second and third premolars have incomplete internal cingula, a character confined to the higher genus *Telmatotherium*. Consequently in this variety we see two lines of variation: one tending toward *Limnohyops* and the other toward *Telmatotherium*.

There is a very interesting lower jaw in the collection, No. 10,018, in which the cones of the molars are higher than in the typical form. This applies especially to molar 3, where the crown is very narrow and the posterior tubercle unusually large for this species, being as broad transversely as the whole crown of the tooth in front, while in the typical form this tubercle is merely a cone. The variation in the character of the dentition of the above jaw would lead us to consider that this is a variety tending toward *Telmatotherium*, as indicated by the elongated and increased height of the crowns of the last molar.

Palæosyops lævidens is probably lower in phylogenetic position than *P. paludosus*, as its superior premolar 2 has only one external lobe and this tooth is simpler than in any other species of this subfamily. The intermediate tubercles of *P. lævidens* are reduced; its last superior molar exhibits a small cone at the posterior internal angle of the tooth. One character of the skull of *P. lævidens*, to be described later, indicate that the species is more closely related to *L. laticeps* than to *P. paludosus*. In the characters of its skull *P. megarhinus* departs widely from *P. paludosus*, but its rather low crowned molars without external cingula indicate that it is, perhaps, more closely related to the latter species than to any other, although its cranial characters show it to be an aberrant form of the genus.

Prof. Cope's *P. vallidens* is a very interesting species, and its dental characters indicate that it ought to be placed near *Telmatotherium*. This is proven by the characters of the lower molars which have high and elongated crowns, thus departing widely from the molars of *P. paludosus*, although the species shows its close affinity to the latter in the cone-like form of the posterior tubercle of inferior molar 3. The characters of the jaw of *P. vallidens* are clearly Telmatotheroid. The phylogenetic position of *P. vallidens* is therefore between *P. paludosus* and *Telmatotherium*, although as a whole this species shows closer relationship to the latter genus.

I regard *P. minor* as being much more closely related to *Telmatotherium* than to *P. paludosus*, because of the high crowns of its superior molars

[1] Tertiary Vertebrata, plate LI, fig. 2.

which have the broad and flat V's so characteristic of *Telmatotherium.* The external cingula are a conspicuous feature of the upper teeth in *Palæosyops minor*. On all the true molars of *P. minor* the intermediate tubercles are much reduced, which is surely a Telmatotheroid character. Its superior true molars show affinity to *P. paludosus* in the form of molar 3 whose posterior internal angle is very obliquely cut off, this tooth not having the square form which is so characteristic of *Telmatotherium.* Premolar 4 and molar 1 show a considerable difference in size; the superior premolars 1 and 2 show decidedly more affinity in form to the teeth of *Telmatotherium* than to those of *P. paludosus*, this especially holding good for the first premolar which is elongated and has the canine-like form so characteristic of *Telmatotherium.* The superior premolars of *P. minor* still retain an incomplete internal cingulum, which indicates its affinity to *Palæosyops.* The external lobes of the premolars in *P. minor* are decidedly of a Telmatotheroid pattern having high crowns not separated by a buttress and provided with external cingula; the last inferior premolar is more developed in this species than in *P. paludosus*, as shown by the size of the V's which are plainly marked off in the last tooth of this series, their connecting crests being large and sharp. This character of their crowns places them higher in the scale of development than the teeth of *P. paludosus* where inferior premolar 4 is less developed. The lower molars of *P. minor* are rather more intermediate in character than the upper ones; their crowns are comparatively low; the posterior tubercle of the last molar is very much degenerated but has not reached the cone stage, as the tubercle still retains traces of a valley and lateral crest. The V's of these molars are well expressed and their crests more sharply defined than in *P. paludosus.* The dental characters of *P. minor*, therefore, indicate that this species holds an intermediate position between typical *P. paludosus* and *Telmatotherium*, although I think it is probable that *P. minor* was derived from *P. paludosus*, or may have arisen directly from *P. borealis*, in the latter case developing parallel with *Telmatotherium* and not leading directly to it, a view rendered probable by its small size. It is, however, more probable that *P. vallidens* and certain varieties of *P. paludosus* are the direct transition forms between the latter and *Telmatotherium.* The characters of the lower molars of *P. longirostris* prove that this species is closely related to *P. minor.*

If I had followed strictly the chronological appearance of the species of *Palæosyops* I should have been forced to consider *P. borealis* first, but as the characters of the teeth in this species more strongly resemble in my opinion, those of *Telmatotherium* than those of *Palæosyops*, I shall therefore deviate from the ordinary arrangement which I have followed and consider the characters of *P. borealis* here. The first superior molar of this species reminds one strongly in its general form of that tooth in the genus *Telmatotherium.* It is square with rather broad external V's, the latter being shallow and broad as in *Telmatotherium.* The protoconules of molars 1 and 2 are small. In the first molar the posterior intermediate is wanting, or rather the slight ridge developed on the posterior part of this tooth is the homologue of that conule. The last upper molar in *P. borealis* is badly damaged, but enough remains to show the characters of its external V's, which are broad and flat. The only premolar preserved has its external lobes straight; the internal lobes are rather primitive in character, being very broad, blunt, and with the internal cingulum incomplete. The dental characters of *P. borealis* indicate that the species is more closely related to *P. minor* than to *P. paludosus*, and probably may have been the direct ancestor of the former, this subline as it were, having branched off from the *Lambdotherium* stem earlier in its evolution. I believe that many of the transition forms between *Lambdotherium* and *Palæosyops paludosus* are still wanting.

I cannot agree with Prof. Cope[1] in placing the genus *Telmatotherium* (=*Leurocephalus*, lower than *Palæosyops* in the scale of evolution. In determining the phylogenetic position of a genus, we should first consider it as a whole, and not limit ourselves to one single dental character in order to judge of its position in the system. The absence of a well developed internal lobe from superior premolar 2 in *Telmatotherium cultridens* causes Cope to place this species lower in the scale than *P. paludosus*, although Marsh's *T. validus* has the internal lobe of this premolar well developed. I have already dwelt upon the characters of the teeth in *Telmatotherium* and have shown how much more nearly they approach those of the culminating genus of this line (*Titanotherium*). I therefore hold that *Telmatotherium* in its dental characters shows a decided advance over *Palæosyops*, and a brief summary of these will, I believe, prove the correctness of this position. The crowns of the molars of *Telmatotherium* are very high, and their external lobes exceedingly broad and flat, while practically all traces of the median rib of the external V's have been lost on the upper true molars of the genus. The external median buttresses are strongly constricted off; the lower true molars, likewise, have their cones high, sharp and thin, and their V's strongly developed; this applies especially to the connecting crests, which are strongly raised above the valleys. The posterior tubercle of the last inf. molar is an open and functional lobe; it is not specialized as in *P. paludosus*. The last inferior premolar in *Telmatotherium* approaches more nearly the characters of the true molars than in *Palæosyops*. The intermediate position of *Telmatotherium*[2] together with its close approach to *Diplacodon* in its dentition is thus demonstrated. Because of the internal lobe to sup. premolar 2, I regard the species *T. cultridens* as lower in the scale of its development than *T. validus* where this lobe is strongly developed, although in some respects the former species is more specialized than the latter. That is, *T. cultridens* has the intermediate tubercles nearly wanting, whereas in *T. validus* these tubercles are well developed, and there is a well defined protoconule on superior premolar 4, which is totally wanting in *T. cultridens*. The latter species has also a very rudimentary hypocone

[1] American Naturalist, Dec., 1887, Article Perissodactyla.

[2] A variety or species of *Telmatotherium* in the Princeton collection is represented by jaw No. 10,184. The dental series of this lower jaw is much smaller than that of *T. cultridens*, and the posterior tubercle of molar 3 is intermediate in character between the former species and *P. paludosus*.

upon superior molar 3 which is wanting in that of *T. validus*, although, strange to say, in the latter species this tooth is provided on one side with a well developed metaconule. In *T. cultridens* the internal basal cingulum of the premolars is strongly developed and complete. I regard this completion of the internal cingula of the premolars as being a higher dental character than the incomplete cingula. *T. hyognathus* is the highest species of the genus and is the transition form between *Telmatotherium* and *Diplacodon*, as will be shown later when I consider the evolution of the lower jaw.

The Skull.—The skull presents a great variety of form in this subfamily, and in some species a great development of the occipital crests with an elongation of the cranio-facial axis is the rule, while in other species the skull is shorter, with a tremendous convex development of the frontal region. Owing to the lack of material I am totally unable, unfortunately, to give an idea of the form of the skull in a number of species. *Limnohyops laticeps* has the most primitive form of skull. In this species, as we have already seen, the cranium is greatly drawn out, producing an extremely long cranial region and a short facial portion. The orbits are small and placed well over the alveolar border of the jaw. The occipital crests are more strongly developed than in any other species of the subfamily. The inter-orbital region is hollowed out and culminates in narrow and elongated nasals. In the form of its nasals and strong zygomatic arches *P. lævidens* approaches *L. laticeps* more nearly than any other species. The palate in all the species of this subfamily is short and never extends beyond the second superior molar. The primitive character of the premaxillaries of *L. laticeps* is shown in their short and round form. It is interesting to note that the contour of the skull of *L. laticeps* more closely approaches that of *Titanotherium* than any other species of the *Palæosyopinæ*.

Palæosyops megarhinus appears to have a low grade of skull, its form being elongated and much depressed. The orbits are small and placed far forward. The premaxillary and nasal regions are highly specialized, and differ considerably from those of the more primitive type of skull seen in *P. paludosus*. The characters of the zygomatic arch and malar insertion of *P. megarhinus* differ very much from those of *P. paludosus* and *L. laticeps*. The broad shelf-like malar of *P. megarhinus* is unique in character.

The form of the skull of *P. paludosus* is somewhat specialized and is hardly in conformity with the low type of its dentition. As we see, the marked excavation of the anterior frontal region and its great bulbiform enlargement distinguish it from other allied species of the genus. The facial region is considerably elongated and the temporal fossa shorter and higher than in *L. laticeps*. *P. paludosus* agrees with all the other species of this family in not having the orbit separated from the temporal fossa, constituting a primitive character persisting in all the members of this subfamily. The premaxillaries of *P. paludosus* retain the same primitive form as in *Limnohyops*. The nasals, on the contrary, are shorter and broader than in the latter genus. In all the above mentioned species the auditory processes of the skull remain separated and there is little variation in their form throughout the subfamily. An exception to this rule is seen in the skull of *P. megarhinus* where the postglenoid is very short and thick. The separation of the foramen ovale from the foramen lacerum medium, and the antero-posterior extent of the alisphenoid canal are constant, and primitive characters of all the skulls examined. Lastly a large laterally unossified space borders the basi-occipital region of the skull as in all recent Perissodactyles. I have already called attention in the descriptive part of this memoir to the presence of an ossified tentorium in the skull of *P. megarhinus*, as well as to the reduced size of the brain cavity in the skull of *L. laticeps*. The low condition of the brain and the almost entire separation of its lobes are characters which indicate the low development of the brain in the *Palæosyopinæ*. In *Telmatotherium cultridens* the skull is, as far as we know, rather shorter than that of *P. paludosus*, with its vertical elevation increased. The skull of *T. cultridens* is strongly compressed, especially in the facial region. The nasals are elongated and strongly arched laterally. In the premaxillary region of *Telmatotherium* is found a highly specialized portion of the skull; and perhaps in *P. megarhinus*, where the premaxillary symphysis is rather more elongated and narrow than in *P. paludosus*, we have a kind of transition form between the two genera in the premaxillary region. This is the only variation of the premaxillary region in *Palæosyops* resembling that of *Telmatotherium*. A very interesting character of the skull of *Telmatotherium* is the slender and nearly straight zygomatic arch which agrees in form almost exactly with that of *Diplacodon*.

Evolution of Jaw Symphysis.—The series of changes which the symphysis of the lower jaw has undergone in this series is interesting. It commences in *P. paludosus* which has a rather short symphysis, rounded and not horizontally placed. The diameter of the jaw behind premolar 1 is considerable but the accompanying table shows that it decreases and then enlarges again in the jaw of *T. hyognathus*. In *P. paludosus* there is no post-canine diastema but the post-premolar 1 diastema is well developed. There is a great deal of variation in the size of the diastemas in *P. paludosus*. The next step in the elongation of the jaw is found in a small variety of *Telmatotherium* (Jaw No. 10,184). There is a decided elongation of the symphysis, which is more horizontally placed than in *P. paludosus*, while corresponding with its growth there is an enlargement of the diastemas. The post-canine diastema, which did not exist in *P. paludosus*, has become well marked in this variety. This elongation of the symphysis and increase of the diastemas is continued in *T. cultridens* and through a variety of *T. hyognathus* to the typical jaw of that species No. 10,273, which is the culmination of the line of development. In *T. hyognathus* the symphysis has become much elongated and is markedly procumbent in position while the diastemas have increased very much, so that now the first premolar is widely separated from both the canine and premolar 2. I consider this jaw the next step to *Diplacodon*, although in that genus the first premolar is placed farther posteriorly, there being no post-premolar 1 diastema in the jaw of *D. elatus*. I have placed the type jaw of *T. hyognathus* in the genus *Telmatotherium* because its inferior premolar 4 appears to still retain the simpler character found in all the *Palæosyopinæ*. The following table of measurements will illustrate the variation in the length of the symphyses above described.

MEASUREMENTS TO ILLUSTRATE THE INCREASE IN LENGTH OF JAW SYMPHYSIS.

	P. paludosus No. 10,009.	T. variety No. 10,184.	T. cultridens No. 10,361.	Telmatotherium hyognathus No. 10,274.	No. 10,273.
	M.	M.	M.	M.	M.
Length of symphysis	·092	·108	·115	·115	·130
Breadth behind premolar 1	.065	·043	·050	·055	·060
Length of post-canine diast.	·000	·011	·017	·022	·034
Length of post-premolar 1 diast	·015	·018	·015	·011	·017

The Axial Skeleton.—I have already described the peculiarities of the axial skeleton of *Palæosyops paludosus*. In many respects it resembles that of the Tapir, although in the specialization of the articular processes of the posterior axial region it differs widely from the latter. It was found that the atlas and axis closely resemble those of the Tapir, the former being pierced by two foramina for the first cervical nerve. The transverse process of the atlas is perforated by a large inter-vertebral canal. The vertebræ of the anterior dorsal region are very heavy with strong neural spines; on the posterior part of the dorsal region the vertebral zygapophyses become nearly as involute in form as in some of the Artiodactyles (*Antilocapra*). In this character the vertebræ of *Palæosyops* depart widely from all recent Perissodactyles except *Equus* which has the zygapophyses of the posterior dorsal and lumbar regions involute in form.

Appendicular Skeleton.—The general form of the scapula is, as far as known, constant throughout this subfamily. In *P. paludosus* it was rather broader and heavier than in *L. laticeps* where the spine of the scapula was quite oblique in position. The primitive character of the scapula in this subfamily as compared with that of recent Perissodactyles is indicated in the want of a coraco-scapular notch, by the presence of a large tuberosity for muscular insertion and, most important, the large development of the coracoid process. The form of the scapula of *Palæosyops* is found to be rather intermediate between that of *Tapirus* and *Rhinoceros*. The trochleæ of the humerus, in form and subdivision, are rather different from those of the Tapir, the internal trochlea being large and more oblique in position, whereas the external part of the external trochlea is bevelled off instead of being concave as in the Tapir. This is also the case in the smaller species of the genus. In *P. paludosus* the internal trochlea is very large and broad, while the external has a tendency to become rounded, and does not show its subdivisions as plainly as in the larger species. This character is more strongly marked in the Rhinoceros where the external trochlea has no bevelled portion, this face being vertical.

There is considerable variation in the form of the carpus in this group. In *P. paludosus* it is shorter and broader than in *L. laticeps*. In the former species the distal facets of the lunar are more nearly subequal and the distal portion of the lunar does not penetrate so deeply into the second row of carpals. The metapodials of *P. paludosus* are short and heavy and the manus as a whole approaches more nearly the Paraxonic type than in *L. laticeps*. The carpus of *P. minor* closely resembles that of *P. paludosus*. *Limnohyops laticeps*, on the other hand, shows the most highly specialized carpus of the group, and it is interesting to note that in this respect it agrees with the supposed ancestral forms of the *Palæosyopinæ* :—*Lambdotherium popoagicum* and *Palæosyops borealis*, which are the earliest known members of this line. In these two forms the lunar is much elongated and its magnum facet is nearly vertical in position, which is equally true of *L. laticeps*, where, however, it is still farther elongated, its distal extremity being drawn out and deeply penetrating the second row of carpals. In the manus of *L. laticeps* there is a decided inclination to Mesaxonia, much more so than in the hand of *P. paludosus*. The fifth digit of *L. laticeps* is much shorter than the others although not as much reduced as that of the Tapir's carpus. The characters of the carpus of *L. laticeps*, therefore, are not as primitive as those of the dentition, the species in this respect agreeing with the earlier ancestors of the group, and again proving that an animal may be highly specialized in some portions of its structure, although in other characters it may be very primitive.

The proportions and size of the facets of the tarsus undergo a great deal of variation in this subfamily. In *P. paludosus* and *P. minor* the tarsus is broader in proportion to its length than in *L. laticeps*. As a rule the facets of the astragalus and calcaneum are continuous in the smaller species, and as we approach the larger they become separated. In *Titanotherium*, the most highly specialized genus of the group, the sustentacular, inferior and ectal facets are widely separated from each other. *Palæosyops paludosus* stands intermediate between such forms as *Limnohyops laticeps* and *P. minor*, in which these facets are continuous, and *Diplacodon* and *Titanotherium* in which the tarsal facets are widely separated. The astragalo-cuboid contact is also another variable character of the tarsus. In *L. laticeps* and *P. minor* it is small, whereas in *P. paludosus* it is large, and increases proportionately with the transverse extent of the proximal elements of the tarsus. This is seen in the tarsus of *Titanotherium* where the astragalus covers about one-half of the cuboid. A fibulo-calcaneum facet is a rather constant character in this subfamily. There is generally no contact between the cuboid and metatarsal III, although in a tarsus in the Princeton collection from the Bridger, the specific identity of which cannot be determined, there is a considerable contact between the cuboid and this metatarsal. The proximal portion of metatarsal III is generally narrow transversely, with plane articulating surfaces, but in *L. laticeps* the articulation between metatarsal III and IV is highly specialized in the form of an interlocking joint. The shape of the ectocuneiform is high and narrow and is characteristic of this group. We have seen that in this subfamily the reverse type of tarsal articulation never occurs.

In the following tables I have arranged the primitive and specialized characters occurring in this group in columns, but no one species contains all primitive characters. The dentition, for example, may be highly specialized while the carpus or tarsus may not have undergone as much displacement as in another form where the dentition is more primitive.

PRIMITIVE CHARACTERS.

1. Incisors without strong basal cingula.
2. Canines rather short and stout without cutting edges.
3. Superior premolar 1 a cone without prominent heel; inferior premolar 1 also simple.
4. Superior premolar 2 with only one external lobe and with internal lobe wanting. Inferior premolar 2 with lobes subequal.
5. Inferior premolar 3 without a metaconid.
6. Superior premolar 4 with transverse diameter much less than that of molar 1, also with external lobes not separated by a buttress. Inferior premolar 4 with V's not strongly expressed.
7. Crowns of molars strongly brachydont with external V's rounded, narrow and with a median rib present. Median buttress not constricted off and with anterior buttress strongly prolonged. Lower molars with crests of V's not prominent. Last inferior molar with its posterior tubercle a functional lobe.
8. Intermediate tubercles of premolars and molars large and, in the most primitive form, with protoconule and metaconule present on upper true molars (*Limnohyops*).

PROGRESSIVE CHARACTERS.

1. Incisors with strong basal cingula. Posterior face of incisors vertical.
2. Canines elongated, slender and with sharp cutting edges.
3. Superior premolar 1 elongated, with anterior and posterior tubercles.
4. Superior premolar 2 with two well developed external lobes. Internal lobe of same present. Anterior lobe of inferior premolar 2 much larger than posterior.
5. Inferior premolar 3 with a metaconid (*Lambdotherium*).
6. Superior premolar 4 with transverse diameter nearly equal to that of molar 1. External lobes of premolar 4 separated by a buttress. Inferior premolar 4 with V's well developed but without an entoconid.
7. Crowns of molars high, with external V's very broad and angular. Median rib of same absent. Median buttress strongly constricted off. Anterior buttress not widely prolonged. Crests of lower molars very high and sharp. Last inferior molar with posterior tubercle specialized in the form of a cone without crests and valley.
8. Intermediate tubercles of superior premolars and molars much reduced.
9. Last superior molar with only one internal cone.

9. Last superior molar with two internal cones.
10. Superior and inferior diastemas small.
11. Form of skull much elongated and depressed. Occipital region higher than the interorbital and provided with large crests. Orbit small and placed well forward over molars. Floor of orbit short. Zygomatic arch strongly developed. Auditory processes well separated. Palate short. Premaxillaries short and with a short, round symphysis. Nasals elongated and of the same breadth throughout. Alisphenoid canal long. Foramen ovale separated from foramen lacerum medium. Symphysis of lower jaw short and rounded.
12. Cranial cavity elongated, with cerebral and cerebellar fossæ separated by an *ossified tentorium*.
13. Brain of a low type. Divisions of same well separated, with olfactory lobes much elongated. Cerebellum and medulla very broad transversely.
14. Atlas perforated by a vertebrarterial canal.
15. Scapula with a large coracoid process.
16. Pelvis with iliac portion not subdivided.
17. Carpus short and broad, with distal facets of lunar subequal. The four digits of the manus well developed. Manus approaching the Paraxonic type.
18. Tarsus with facets of astragalus and calcaneum continuous. Astragalo-cuboid contact small. No interlocking articulation between metatarsals. A fibulo-calcaneal facet present.

10. Superior and inferior diastemas large.
11. Form of skull may be variously modified. Crests not strongly developed. Orbit and floor of same much elongated. Zygomatic arch nearly straight and slender. Auditory processes nearly approaching each other. Mastoid portion of periotic not exposed. Premaxillaries much elongated and high, with a long median symphysis. Nasal short and broad, expanded distally. Symphysis of lower jaw nearly horizontal in position and very long.
12. Carpus narrow and elongated. Distal facets of lunar highly specialized, the lunar-magnum facet being very small and nearly vertical in position. Lunar-unciform facet large. Magnum high and narrow. Manus approaching the Mesaxonic type with metacarpal III larger than the others. Metacarpal V quite reduced.
13. Distal humeral trochleæ specialized.
14. Pre- and postzygapophyses of posterior dorsal and lumbar vertebræ involute in form.
15. Scapula with an oblique external spine.
16. Tarsus with facets of astragalus and calcaneum widely separated. Inferior facet small. Astragalo-cuboid contact large. Metatarsals III and IV may have interlocking articulations. Fibulo-calcaneal contact reduced. Navicular shallow. A large contact between cuboid and metatarsal III.

CONCLUSIONS.

The foregoing study of the relationship of the members of this subfamily lead to the following conclusions as to their phylogeny :—

1. That *Lambdotherium* may be the ancestor of the Palæosyops–Diplacodon line, although certain specialized characters of its dentition, the loss of the first inferior premolar and the more complex development of its inferior premolar 3 indicate that *Lambdotherium* leads to a side line.

2. *Palæosyops borealis* appears to lead to a side line, perhaps to *P. minor*. The molars of *P. borealis* point to this conclusion because of their close resemblance to those of *Telmatotherium*.

3. I consider that *Limnohyops laticeps* is the most primitive member of this group from the Bridger, because of its low form of molar, with large intermediate tubercles, and its last superior molar has two internal cones. The form of the less specialized skull of *L. laticeps*, with short premaxillaries and much elongated nasals, points to the primitive position of that species. From such a form I believe *P. lævidens* has arisen, that species being intermediate between *L. laticeps* and *P. paludosus*.

4. *P. paludosus* has arisen from *L. laticeps* through the intervention of *P. lævidens*; in the latter the simplification of its superior premolar 2 is greater than in *P. paludosus*.

5. *P. vallidens* has developed from *P. paludosus* by lengthening and increasing the height of its molars.

6. *Telmatotherium cultridens* has originated by increase in height of the crowns of the molars and widening of the external V's, and a reduction of the intermediate tubercles of *P. paludosus*. *P. vallidens* is the transition form between these two species.

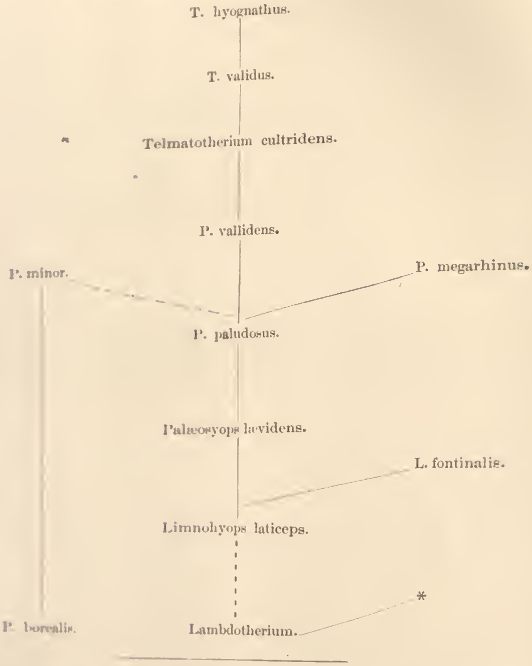
7. *T. cultridens*, on account of the simpler structure of its superior premolar 2, is the most primitive member of the genus *Telmatotherium*, and was the ancestor of *T. validus*.

8. By lengthening of the jaw symphysis of *T. validus*, with a concomitant widening of its diastema, *T. hyognathus* has arisen.

9. I regard *L. fontinalis* and *P. megarhinus* as specialized forms and not in the direct line of descent leading to *Telmatotherium*.

10. As already mentioned several times in this memoir I consider that *Telmatotherium* is the most highly specialized genus of the *Palæosyopinæ*, approaching more closely in its dental characters to *Diplacodon* than any other genus of the subfamily. *Telmatotherium* should, therefore, hold an intermediate position between *Palæosyops* and *Diplacodon*.

The accompanying phylogenetic table will make clear the supposed relationships between the species of this subfamily.



APPENDIX.

FURTHER OBSERVATIONS UPON THE OSTEOLOGY OF PALÆOSYOPS BOREALIS.

I am able to make an additional contribution to the osteology of this species, owing to the fact that the expedition sent out last summer by the American Museum of Natural History to the Wind River and Wasatch Eocene, procured, among the numerous other beautiful specimens, the greater part of a skeleton of *Palæosyops borealis.*

I am indebted to the gentleman of the vertebrate palæontological department of the Museum for allowing me to study this important specimen.

Additional Specific Characters.—Mandible with a diastema posterior to premolar 1. Anterior diastema small. Last inferior molar with posterior tubercle much reduced and cone shaped. Crowns of inferior molars low and broad.

Skeleton.—The lower jaw of *P. borealis* is rather long and slender. The ascending ramus is high. The symphysis is long and constricted at the diastema. The canines are round in section and wide spreading. The protoconid of premolar 2 is much higher than in the other premolars. It has a well developed heel. The true molars show their primitive character in having low crowns, with the crests of the V's low, and the valleys shallow. The characters of the last inferior molar are of interest; and its posterior tubercle is more reduced than in any species of the genus.

Humerus.—The humerus is slightly shorter than in *Tapirus Americanus*, but the extent of its proximal and distal surfaces much less. The middle portion of the shaft is slender. The deltoid ridge extends far down upon the shaft, and its external border is prominent. The trochleæ are very narrow transversely, with a prominent rounded ridge dividing the external from the internal.

Femur.—The femur is much shorter than that of the American Tapir; its shaft is long and slender. The lesser trochanter is prominent. The third trochanter is elongated and thin. As in all the species of *Palæosyops* the postero-inferior face of the femur is flat and shows no fossa for muscular insertion.

Manus.—The carpus is about as broad as high. The lunar has a large contact with the unciform, but does not penetrate below as in *Limnohyops*. The magnum is very high and narrow, and only has a small contact with the lunar. The unciform is Tapiroid in form, and its horizontal axis is rotated more upward than in the other species of the subfamily. As a result of these carpal relations the unciform-lunar contact is a large one. Indications are that the outer digit of this species was more reduced than in *L. laticeps*; and the axis of the manus passes through metacarpal III (Mesaxonia). The metapodials are wide spreading and slender. From the measurements of the jaw and limb bones, we may conclude that this graceful species must have been about one-fifth smaller than the Brazilian Tapir, but the diameter of the limb bones and the light construction of the manus prove that it was lighter built and more agile than any of the recent species of Tapir.

MEASUREMENTS, PALÆOSYOPS BOREALIS, NO. 296.

	M.
Length of jaw	·260
Depth below middle of molar 3	·046
Entire inferior molar series	·128
Length of manus without phalanges	·117
Length of carpus	·034
Breadth of carpus	·035
Lunar { height	·021
Lunar { breadth (above)	·017
Length of humerus	·205
Breadth of distal surface	·046
Length of femur	·255

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EXPLANATION OF PLATES.

All specimens are in the Princeton Collection unless otherwise specified.

Plate X.

Fig. 1. Palæosyops paludosus.
Skull, lateral view; so. supraoccipital. Academy of Natural Sciences, Philadelphia.
Fig. 2. Palæosyops megarhinus.
Skull, lateral view.
Fig. 3. Telmatotherium cultridens.
Skull, lateral view.

Plate XI.

Fig. 4–7. Palæosyops megarhinus.
Fig. 4. Skull, anterior view.
Fig. 5. Skull, basal view; as. posterior opening of alisphenoid canal; f. o. foramen ovale; f. l. m. foramen lacerum medium; f. l. p. foramen lacerum posterius; e. a. m. external auditory meatus; c. f. condylar foramen; Per. periotic.
Fig. 6. Lateral view of brain cast; sy. sylvian fissure; ss. suprasylvian fissure; h. hippocampal gyrus.
Fig. 7. Superior view of brain; l. l. lateral lobe of cerebellum; v. vermes.
Fig. 8–9. Limnohyops laticeps.
Fig. 8. Skull, posterior view; f. pm. paramastoid foramen.
Fig. 9. Skull, lateral view.
Fig. 10–11. Telmatotherium hyognathus.
Fig. 10. Lower jaw, lateral view.
Fig. 11. The same, superior view.

Plate XII.

Fig. 12–13. Telmatotherium cultridens.
Fig. 12. Superior molars, crown view.
Fig. 13. Inferior molars, crown view; both these figures are taken from the skull figured on Plate X, Fig. 3.
Fig. 14–16. Palæosyops minor.
Fig. 14. Superior molars, crown view. This series of molars is the type of this species, and is in the collection of the Academy of Natural Sciences of Philadelphia
Fig. 15. Second and third molars of same series, external view; ab. anterior buttress; mb. median buttress; cg. external cingulum.
Fig. 16. Milk molars, crown view.
Fig. 17–23. Palæosyops paludosus.
Fig. 17. Superior molars, crown view.
Fig. 18. Superior molar 3, crown view; pl. protoconule; ml. metaconule; cg. cingulum.
Fig. 19. A left superior molar 2, crown view.
Fig. 20. An inferior molar 2, crown view. Figs. 19 and 20 are taken from Leidy's original type specimens, in the National Museum.
Fig. 21. Distal end of left radius, anterior view.
Fig. 22. Distal view of same; l. articular surface for lunar; s. that for scaphoid.
Fig. 23. Sacrum, internal view.
Fig. 24–27. Limnohyops laticeps.
Fig. 24. Right scapula, external view; tb. tuberosity; cr. coracoid process.
Fig. 25. Left humerus, anterior view; e. c. external condyle; i. c. internal condyle.
Fig. 26. Left radius and ulna, anterior view.
Fig. 27. Distal view of same. Last two figures are from the same individual as manus, Plate XIV, Fig. 39.

Plate XIII.

Fig. 28–38. Palaeosyops paludosus.

Fig. 28. Atlas, anterior view; v. vertebrarterial canal.
Fig. 29. Atlas, superior view; s. n. foramina for first spinal nerve.
Fig. 30. Axis, lateral view.
Fig. 31. A cervical vertebra, anterior view.
Fig. 32. An anterior dorsal vertebra, anterior view.
Fig. 33. Lateral view of same.
Fig. 34. A posterior dorsal vertebra, lateral view.
Fig. 35. Posterior view of same; pz. postzygapophysis.
Fig. 36. Lumbar vertebra, lateral view; pz. postzygapophysis; m. metapophysis.
Fig. 37. Right scapula, external view.
Fig. 38. View of the glenoid cavity of the same.

Plate XIV.

Fig. 39–42. Limnohyops laticeps.

Fig. 39. Left manus, anterior view.
Fig. 40. First row of carpals of same, distal view; s. scaphoid; l. lunar; c. cuneiform; tz. facet for the trapezium; td. facet for the trapezoid; mg. the two anterior facets for the magnum; t. m. the two posterior facets for the same; uc. facet on the lunar for the unciform.
Fig. 41. Right pes, anterior view; f. b. fibulo-calcaneal facet.
Fig. 42. A right metacarpal III, anterior view; from same individual as the last figure.

Fig. 43–44. Palaeosyops minor.

Fig. 43. Right pes, anterior view.
Fig. 44. Metatarsals, proximal view; c''' facets for ectocuneiform.

Fig. 45–49. Palaeosyops paludosus.

Fig. 45. Left manus, anterior view; this figure is a composition.
Fig. 46. Left pes, anterior view; a composition.
Fig. 47. Left calcaneum and astragalus, lateral view; a. cb. astragalo-cuboid-facet.
Fig. 48. Anterior view of same.
Fig. 49. Left cuboid, anterior view; c. c. calcaneal facet; c. as. astragalar facet; c. uv. facets for ectocuneiform; from same individual as figure 47.

A STUDY OF THE FOSSIL AVIFAUNA OF THE EQUUS BEDS OF THE OREGON DESERT.

By R. W. Shufeldt, M. D.

Early in March, 1891, Professor E. D. Cope placed in my hands for description two collections of fossil Birds. Both of these were obtained at Fossil and Silver Lakes in Oregon. The first consisted of some seventy or eighty specimens belonging to the private cabinets of Professor Thomas Condon of Eugene City, Oregon, and were collected by him in the aforesaid region; the second, and by far the larger collection, consisting of several hundred specimens, belonging to Professor Cope himself, having also been collected at Silver Lake either by himself or his assistants.

Soon after these collections came into my possession I bestowed upon them a preliminary examination of quite a superficial character. Nevertheless it was sufficient to enable me to present the results of such an initiatory study in a paper entitled "On a Collection of Fossil Birds from the Equus Beds of Oregon" which was read by me before the Biological Society of Washington at its regular meeting on the evening of the 21st of March, 1891, and was subsequently published in the April number (of the same year) of *The American Naturalist* without change of title (pp. 359–362).

Professor Cope, prior to submitting these collections to me for a description, had given an account of three new forms of birds they represented and had determined some seven others as having belonged to species considered by him to be identical with species now existing in our avifauna. Those accounts have been published in various places, and it has been from such sources, taken in connection with my conversations with their author, that most of my first information of the kinds of birds that flourished in those times, and all my information about the region in which they were procured, was derived. With respect to my knowledge of the locality, it was principally obtained from his paper in the issue of *The American Naturalist* of November, 1889, entitled "The Silver Lake of Oregon and its Region"; and the other papers I shall refer to farther on.

On the 13th of March, 1891, Professor Condon wrote me from Eugene City, Oregon, giving me permission to retain in my keeping such specimens as belonged to him, until the entire collection was described and printed. My thanks are here tendered him for his courtesy and assistance.

THE SILVER LAKE REGION.

Two figures of Silver Lake are presented in Cope's article in *The American Naturalist* named above, and I learn from still other sources that that sheet of water is approximately found in latitude 43° 05' N. and longitude 43° 25' W., being somewhat to the southward of the middle part of the State. It has an extreme length not exceeding twelve miles, its greatest width being not more than eight or nine. While its own waters are alkaline, it has, nevertheless, fresh water passing into it from Silver Creek over a swampy delta near its northwestern extremity, and a small, clear stream of pure water also enters it from the westward.

Abert's Lake, considerably larger than Silver Lake, is found some forty-five miles to the southward and eastward of it, while at various distances from the latter and in divers directions in the same region are to be found similar ones, all agreeing more or less with them in their character. Fossil Lake is more in the Oregon desert region, and is about forty miles east of Silver Lake, and is a lake now only in name, for its former waters have long since dried up. By digging, however, water may yet be obtained at a depth of two or three feet from the surface of the ground, or what was formerly the bottom of the lake. The surrounding country is covered with "sage brush", and presents the usual topography of the western desert region. But Silver Lake is bounded on the west and east by precipitous basaltic bluffs, which, on the south, present their dip edges to the lake, the general strike being north and south. Cope has further said that "on the north side this lake is bounded by a range of low hills, terminating in a bold flat-topped butte to the east, which is composed of volcanic mud more or less irregularly stratified. A low shore and plain separate this range from the eastern bluffs, and at this point overflow from the lake reaches a low tract to the eastward, which, when it contains water, is known as Thorne's Lake. It was dry at the time of my visit (1879)".

"On climbing the bluff which bounds the lake on the west, the observer stands on the edge of a plain which extends to the foot of the ancient volcano which I passed on the way to the lake. It is here seen to form but a single mountain with its foothills, forming a line north and south. It occupies the position of the so-called "Winter Range" of the U. S. War Department maps; but it is rather entitled to be called Winter Mountain than a "range". Its summit is bold, but had no snow on it at the time of my visit. Its slopes are thickly clothed with forest pine (*Pinus ponderosa*)".

"From the summit of the bluffs on the east, the eye ranges over the Sage-brush desert of Central Oregon. Its surface is diversified by hills and bluffs, which have generally one slope, and one precipitous side running generally north and south. The surface was everywhere dotted with the ubiquitous Sage-brush (*Artemisia*), with here and there a generally distorted cedar (*Juniperus*). This scene extended as far as the eye could reach, being bounded on the northeast by the long, low outline of the Wagontire Mountain".

Most of the best specimens are found at Fossil Lake, and as I have already said in another connection, that region was first visited by the cattlemen of the vicinity, and they collected, as objects of curiosity, most of the fossil bones of vertebrates, thus forever depriving science of them and their study. Professor

Thomas Condon was the first scientific man that visited Fossil Lake, with the result already stated above. Cope and his assistant, Mr. Charles H. Sternberg, came later, and gathered up many hundreds of bones and fragments of them. By them the name of the Silver Lake Region has been applied to the entire country about, and for our present purpose its character has now been sufficiently well portrayed in the foregoing paragraphs.

OBSERVATIONS ON THE PRESENT FAUNA OF THE REGION.

At the small lake known as Christmas Lake, one of the system now under consideration, Cope found in its waters "abundance of larvæ of dipterous insects, and crustaceans, as Cyclops", and various waders among the birds were feeding upon these. Quantities of small white shells also abound; they are principally of the species known as *Carinifex newberryi*, and they occur both in the fossil and living state. In some places the former bottoms of the lakes are white with them, and undoubtedly they too contributed to the food-supply of many of the tertiary birds and mammals. At the present time *Carinifex* lives chiefly in Klamath Lake. But few varieties of fishes are found. Plenty of *Salmo purpuratus* are to be found in Silver Creek, which, as I have said, empties into Silver Lake, but they do not enter the lake, owing to the alkalinity of its waters. But in the latter we find another form, and only one, it being *Myloleucus formosus* of Girard, one of the *Cyprinidæ*. Batrachians also are rare, but one species has thus far been taken in the region, and that a tree-frog (*Hyla regilla*). It is abundant on the shores of Silver Lake, though it does not resort to the timber. But two lizards have thus far been reported, namely, *Uta stansburiana* and a variety of *Sceloporus undulatus*. The latter is frequently seen sunning itself on the bare volcanic rock of the lake-shores. Only two snakes occur in this arid region,—the rattle-snake, known as *Crotalus confluentus lecontei*, and *Eutænia sirtalis parietalis*.

Bird-life, however, is abundant, and at all times of the day are to be seen, either on the surface of the water, or in the marshes and on the lake-shores several species of the western forms of Grebes; probably gulls and terns; always pelicans and cormorants; nearly every variety of the anserine types, including plenty of swans and geese. Various waders also occur, and I presume, although Professor Cope does not mention them, numerous shore-birds, as plovers and sand-pipers. Coots also are common in suitable places, and very likely some of the Rails. Owls were noted, and among the *Accipitres* various hawks undoubtedly resort there attracted by the great abundance of game.

Among the land birds, *Myiadestes townsendii*, *Hesperocichla nævia*, *Oroscoptes montanus*, and the woodpecker *Melanerpes torquatus*, attracted most attention, but I have every reason to believe that numerous other *Passeres* make up the list.

Many of the Mammalia are abundant; chief among these are the Black-tail deer; the antelope; *Canis latrans*; with badgers and skunks. Rodents are especially numerous, as *Thomomys bulbivorus*; *Tamias a. quadrivittatus*; a small species of *Spermophilus*; at least four hares, namely, *Lepus campestris*, *L. callotis*, *L. silvaticus*, and *L. trowbridgii*. Others than these Professor Cope does not mention as having been seen by him.

Probably some few of the smaller mammalian types were overlooked, but what has just been given will be sufficient to indicate the kind of mammals which at the present time are associated with the existing avifauna.

BRIEF REMARKS UPON THE PREHISTORIC VERTEBRATE LIFE OF THE REGION, EXCLUSIVE OF BIRDS.

The Silver Lake region of Oregon is considered to be of the latest Tertiary formation, of the horizon known as the Equus Beds. These beds exist in other parts of North America, but those furnishing the greatest number of Vertebrate fossils exist in addition to the locality now under consideration, in the valley of Mexico, and in Southwestern Texas.

The Oregon collection furnished Professor Cope with several fossil fish forms, the majority of which were new to science. These were *Leucus altarcus*, *Myloleucus gibbarcus*, *Cliola augustarca*, *Catostomus labiatus*, and *C. batrachops*.

Fossil Mammalia of the region were particularly remarkable, the following being a list of them:

Holomeniscus vitakerianus Cope.
Holomeniscus hesternus Leidy.
Eschatius longirostris Cope.
Eschatius conidens Cope.
Equus major DeKay.
Equus occidentalis Leidy.
Equus excelsus Leidy.
Elephas primigenius Blum.
Canis latrans Say.
Lutra ? piscinaria Leidy.
Castor fiber L.
Arvicola sp.
Thomomys bulbivorus Licht.
Thomomys ? clusius Coues.
Mylodon sodalis Cope.

The phalange of a bear was also found, and as there were numerous fossil bones of mammals and fishes and other vertebrates commingled with the bones of fossil birds sent on to me, I can further say that the above list could be extended by a number of the smaller rodentia such as rabbits, gophers and others.

It will be observed that there is an absence of tapirs, peccaries, opossums and raccoons, which, as Cope says, "one would find in similar company in corresponding beds in the Eastern States".

As to the presence or absence of man the authority just quoted says, "Scattered everywhere in the deposit were the obsidian implements of human manufacture. Some of these were of inferior, others of superior workmanship, and many of them were covered with a patine of no great thickness, which completely replaced the natural lustre of the surface. Other specimens were as bright as when first made. The abundance of these flints was remarkable, and suggested that they had been shot at the game, both winged and otherwise, that had in former times frequented the lake. Their general absence from the soil of the surrounding region added strength to this supposition. Of course it was impossible to prove the contemporaneity of the flints with animals with whose bones they were mingled, under the circumstances of the mobility of the stratum in which they all occurred. But had they been other than human flints, no question as to their contemporaneity would have arisen. Similar flints have been found by Mr. W. T. McGee in beds in Nevada, which he regards as of identical age with that of Silver Lake; but whether diagnostic vertebrate fossils are found at that locality, does not appear to be known. The probability of the association is, however, greatly increased by the discovery, by Mr. Wm. Taylor, of paleolithic flints in beds of corresponding age, on the San Diego Creek, Texas ".[1]

This point interested me not a little and when I came to go carefully over the great mass of fossil bird bones, every fragment and bone was carefully examined for any indications whatever of their former owners ever having sustained any wounds or fractures of the same, but nothing of the kind was discovered. In this connection I would say, though in no way whatever as a counter-argument to the remarks of Professor Cope as given above, that it is by no means an infrequent occurrence to find in the old skeletons of the buffalo on our western plains, Indian iron arrow-heads sticking in some one of the bones. Bullets are also found occupying similar places. It would be too great a digression to further discuss such a point here, and it but remains to be said, that it yet lies quite within the range of possibilities to meet with the fossil bone of some large mammal or bird of Silver Lake, in which may be imbedded the point of a flint arrow-head.

AS TO THE NATURE AND CONDITION OF THIS COLLECTION OF FOSSIL BIRDS.

If we select Fossil Lake as an example of the character of the ground in which these fossils were obtained, it will be seen from what has been said above, that its former bottom, formed principally of sedimentary deposit, is now dry, loose and very friable. Below this at the depth of a foot or two we come to water.

In one or two instances the fossil skeleton of a single bird, or one or two bones belonging to the same individual were found in the damp soil just above the water. The collector had wrapped such in separate parcels, and they were easily distinguished by me when received, from the fact that they were more or less covered by a very thin layer of clayey mud. Material of that kind was found to be particularly useful and valuable. In the loose and highly mobile surface layer or soil, however, the fossil bones were more or less mixed up, and were apparently collected

[1] *The Amer. Nat.*, Nov. 1889, pp. 979, 980.

by simply gathering them together without regard to the species or individuals to which they belonged. Every specimen was most completely fossilized, absolutely free from anything pertaining to a matrix, and, indeed, exhibited their characters in many cases as well as freshly prepared bones of recent birds. In color they were of a deep leaden hue, almost a dead black in many instances. Many of them were completely black and very brilliant after having just been washed in clear water. All of them were very brittle and easily broken by a slight blow.

I found upon examining the collection that Professor Condon had selected his specimens with especial regard to their being perfect and unbroken examples. They were carefully wrapped in cotton and paper, and as separate objects were valuable as a means of comparison. The main collection, Professor Cope's, was packed in a number of separate boxes of various sizes, and some attempt had been made to identify the bones beyond the species he had already described. Those identifications were not altogether satisfactory to me, and in some instances they had again become mixed up. So, with his permission they were disregarded, and the entire material belonging to him mixed in one mass in a large tray for identification and study by the present writer. So much then for the character of the fossils and their condition. The bones ranged all the way from those of a size belonging to a very large swan to those which evidently had belonged to small passerine types. They were in all stages of completeness from slivers and fragments of all sizes to bones quite perfect in all their parts.

METHODS ADOPTED IN STUDYING SUCH A COLLECTION.

Professor Cope's part of the collection consisted of some 1500 bones and fragments of bones, and by carefully going over it bone by bone, and piece by piece, I eliminated, first, all the fossils that were not from birds. Next all the bones that belonged to the same part of the skeleton, irrespective of family, genus or species, were assorted out into separate lots. This threw all the vertebræ together in one lot, all the femora in another, all the coracoids in still another, and so on until the material was all exhausted.

Following next in order came the identification of groups; this took considerable time, and required no little care. It also proved a check upon the first process and corrected such errors as had then been made. The division into groups demanded the rigid comparison, bone by bone, with the corresponding ones in the skeletons of all the existing types of birds available. In this connection I am under great obligations to the U. S. National Museum, and to Mr. Lucas of its Department of Comparative Anatomy, for the loan of many skeletons of birds to be used for the purpose. My own private cabinets also supplied much material to the same end.

After all this had been done I found coracoids, femora, tibio-tarsi and so forth still in separate lots but so arranged that all those belonging to a particular group of birds, as the *Longipennes*, the *Pygopodes*, the *Anseres* etc. were classed together under the group to which they belonged. For instance, all the coracoids of the Ducks were in one lot; all the coracoids of Grebes in another; all the coracoids of Cormorants in another, and so on for all the other bones of the skeleton, and for the different groups of birds to which they had belonged.

Now by carefully studying all the broken bones and fragments, and the use of splints and strong glue a good number of the fractured bones were restored. In some instances they were made complete, while in others so nearly so as to make specific diagnosis certain. With such work every piece, however small, is of value, and throws light upon the solution of any problem under consideration. Especially is this the case in the long bones of Waders and Herons.

After the collection had been gone over a number of times and studied up to this point, two lots of specimens were set aside not to be used again. One of these contained the fossil bones of vertebrates not birds, and the other a mass of broken fossil bird bones too fragmentary for any further use.

Taking the *Pygopodes* now in hand, I placed all the coracoids, for instance, in one lot that seemed to belong to the same species, then all the tarso-metatarsi in another lot, and so on for all the bones of the skeleton. Group after group was treated in this way, until the entire recognizable part of the collection had been gone over again. In one or two instances this actually showed exactly how many species were represented in a particular group. For example, supposing in thus assorting them I found nine kinds of coracoids of Ducks, then upon assorting the ulnæ of those birds, I also found nine different kinds; then nine kinds of carpo-metacarpi and so on until the Duck bones were all assorted into specific lots. It would be fairly good evidence that I had nine species of fossil Ducks before me. Group after group was thus studied and their bones classified, and when this had been accomplished it resulted in another small lot of bones being set aside as "doubtful". Some of the latter were used again, but after all the species had been either identified or named as extinct and new species there still remained a small lot of bones set aside as "not identified", which lot must remain until more material is collected at Silver Lake for additional light to determine them.

After the collection had been treated in the manner thus described I was able to undertake the determination of the specific forms it represented, and I at once passed to a consideration of the *Pygopodes*.

PYGOPODES.

Prof. Cope found three Grebes represented in the collection and gave it as his opinion that they were *Podiceps occidentalis* Lawr., *Podiceps californicus* Heerm., and *Podilymbus podiceps* Linn. and of the first named he said that "one of the most abundant species was a grebe, which I could not distinguish from the one so commonly seen in Silver Lake, (*Podiceps occidentalis* Lawr."[1])

[1] *The Amer. Nat.*, November, 1889, pp. 978 and 980.

Podiceps occidentalis is more properly known as *Æchmophorus occidentalis* and I find in these collections many fossil bones of it, including parts of the superior mandible and the jaw. There is an especially perfect specimen of its tibio-tarsus in Professor Condon's collection. It agrees in all particulars with an example of the tibio-tarsus of a recently killed specimen of *Æ. occidentalis* before me. Within certain limits the long bones vary somewhat in length, but the majority of the specimens are typical. I found no humerus quite as large as that bone in the existing species, but there are not so very many examples of it in the collection, and probably no larger ones were secured. In the fossil bird too, the distal margin of the ulnar crest, or that border bounding the fossa wherein the pneumatic foramina are found in other birds which possess pneumatic humeri, is rather fuller than it is in the humerus of the existing species. This very slight difference appears to be constant.

Another Grebe which is also quite abundantly represented by its fossil remains is *Colymbus holbœlli*, and it appears to be identical with the existing species bearing that name. It is a notably smaller species than *Æ. occidentalis*, and its fossil remains are easily distinguished from it.

Numerous bones of *Colymbus nigricollis californicus* were also found, and in the case of the long bones of the pectoral limbs of this Grebe, it required especial care to distinguish them from the corresponding ones of the fossil specimens of *Podilymbus podiceps*. They are nearly of a size, but I had ample material before me for comparison. As I have just intimated, the Pied-billed Grebe (*Podilymbus podiceps*) also figured in the ancient avifauna of Silver Lake, and the species probably agreed almost exactly with the form we have with us at the present time. Four humeri (two perfect), three ulnas, two coracoids, and two tibio-tarsi and other bones of the fossil species which I have selected agree in all particulars with the corresponding bones of a specimen of *Podilymbus* in my own collection, obtained by me a number of years ago. There still remain a few fossil Grebe bones in the collection, but, from the lack of material, I cannot at present be certain as to the species to which they belong. They consist of the proximal third of a humerus; three tarso-metatarsi (two perfect); an upper mandible, and a coracoid. They are considerably larger than the corresponding bones in any of the smaller Grebes, and far too small for *C. holbœlli*. Moreover their characters are entirely different. Two of the tarso-metatarsi and the coracoid from their *color* and characters appear to have belonged to the same individual; but possibly the specimen was subadult. I have no skeleton of *Colymbus auritus* Linn. at my command, but I am inclined to think that these bones belonged to a specimen of it, and I mark the species with a query in the subjoined list.

There is no evidence whatever, strange to say, of any species of Loon (*Urinatoridæ*) having existed in the former fauna of the region, and their fossil bones are entirely absent from the collection.

The following *Pygopodes* then, were to be found in the ancient avifauna which we have under consideration :

Æchmophorus occidentalis (Lawr.)
Colymbus holbœlli (Reinh.)
Colymbus auritus Linn (?)
Colymbus nigricollis californicus (Heerm.)
Podilymbus podiceps (Linn.)

LONGIPENNES.

Apparently there was a complete absence of the *Alcidæ* or any forms especially like them, but this was not the case with the Gulls and Terns for there are numerous bones to testify to their presence.

Unfortunately, skulls of Gulls or Terns are entirely missing from this fossil material, nor did I find any vertebræ that could with certainty be said to belong to any larine forms. On the other hand several patterns of the humerus were collected, ranging from those of very small size to one of a large Gull. There are four distinct kinds of coracoids, also varying greatly in size, and there are various tarso-metatarsi, carpo-metacarpi, a finger joint of a Gull, a few tibiæ, but nothing more.

There is a distal two-thirds of a right humerus that is identical in size, form and character with the corresponding bone in the skeleton of *Larus argentatus* (No. 18,167, Coll. U. S. Nat. Mus.), and it undoubtedly belonged to an individual of the species now known as *Larus argentatus smithsonianus* Coues. It is not represented by any other bones.

Next I find a perfect coracoid of a Gull, considerably smaller than the coracoid in *L. argentatus smithsonianus*, but only a trifle smaller than the bone as it occurs in *Larus glaucus*, with which it agrees almost exactly in character. It is the coracoid of the left side. There is also the distal moiety of a left ulna of a Gull apparently of the same size, as it differs in the same proportion with the ulna of *Larus glaucus*, with which it otherwise agrees. I am of the opinion that it belonged to the same species, though perhaps not to the same individual. Two large tibio-tarsi of Gulls are also found,—one lacking the proximal extremity, and one the proximal moiety. These are stouter than the tibio-tarsi in *Larus glaucus* but were not quite as long. Possibly they may have belonged to the same species, which may have had stouter pelvic limbs than *Larus glaucus* although not quite so large a bird. As this fossil coracoid belonged to a Gull considerably larger than *Larus a. smithsonianus*, it could hardly have belonged to *Larus occidentalis*, of which species unfortunately I have no skeleton, but it is about the size, judging from external measurements, of *L. a. smithsonianus*, and probably has a skeleton of nearly similar proportions. The coracoid is too small to have belonged to a *Larus marinus*, and at any rate it is not at all likely that it was that form. Moreover it belonged to a larger bird than *Larus cachinnans*, a species no larger than the common Herring Gull.

Indeed I must believe that there was a large Gull present in the former avifauna of the Silver Lake Region, during later tertiary times, which has since become extinct. It was somewhat smaller than *Larus glaucus*, and if the tibio-tarsi, described above, belonged to the same species, it had stouter and shorter legs.

I propose the name of *Larus robustus* for this now extinct species.

LARUS ROBUSTUS sp. nov.

This species is represented by a coracoid of the left side, which is perfect except for the breaking off of the "costal process," the tip of the scapular process, and a small piece out of the middle of the sternal facet at its lower end. The bone is somewhat shorter and stouter than the corresponding element in *Larus glaucus*, otherwise its characters are almost identically the same. *Larus robustus* was a Gull rather smaller than *L. glaucus* with which it may easily have been closely related. Judging from its coracoid, it differed not a little from the species representing the "Herring Gull" group, as the characters of that bone differ quite perceptibly in them. The coracoids of Gulls, however, of all sizes are very much alike in the matter of characters. Some long bones of the limbs, obtained in the same locality, many possibly have belonged to a species of this Gull. The data at my command will not permit me to say whether this species was abundant during the time in which it existed. (See figs. 1 and 2, Pl. XV). It was discovered by Professor E. D. Cope's assistant, Mr. Charles H. Sternberg, in the Equus Beds of the Silver Lake region, Oregon.

LARUS CALIFORNICUS?

Five coracoids in the collection, more or less imperfect, are of about the right size to have belonged to this species of Gull. There are also the best part of two humeri, perfect as far as they go, and a tarso-metatarsus, all of which may represent this bird. Though carefully compared, the species is only entered here provisionally until more material is secured.

Specimens obtained as in the last described species.

LARUS OREGONUS sp. nov.

This species, now extinct, was about the size of *Larus delawarensis*, and is based upon two humeri both from the left side of two individuals. There is also a perfect, or very nearly perfect, coracoid, and the superior half of another one, together with several tarso-metatarsi, which may have belonged to the same species. The humerus not being perfect I cannot give its length; its shaft is stouter than the humeral shaft in *Larus delawarensis* and the proximal extremity, the whole head of the bone, is almost exactly alike in the extinct and existing species. There is, however, a very good distinguishing character, for the osseous partition that divides that great concavity into two compartments overarched by the ulnar crest, is, in *L. delawarensis*, oblique to the plane of the long axis of the shaft, whereas in *Larus oregonus* it was about parallel. In this character *L. oregonus* agrees with *L. argentatus*, and it is often a very good distinguishing one among Gulls and Terns.

Specimens obtained by Professor Cope in the Equus Beds of Fossil Lake, Oregon.

Larus philadelphia.

A nearly perfect humerus and the distal half of another in Professor Cope's collection agree in all particulars with the humerus of a specimen of this Gull in my own private collection. The species apparently was not abundant during tertiary time in the Silver Lake region, or I must believe more examples would have been found.

This fossil was collected in the same locality as the last described species, by Mr. Charles H. Sternberg,

Xema sabinii.

There is a fine specimen of the left humerus of a Gull of this species in the collection of Professor Condon, which agrees in every detail with the corresponding bone of a specimen of *Xema sabinii* in the collection of the U. S. National Museum (No. 93,429). It too, must have been a rather rare form in the tertiary avifauna of Silver Lake.

This fossil specimen was collected in the Equus Beds of the Silver Lake region of Oregon by Professor Thomas Condon of the University of Oregon at Eugene City.

Sterna elegans?

Professor Cope's collection contains two humeri and three carpo-metacarpi of a large Tern that for the lack of proper material I have not been enabled to fully determine. They may have belonged to this species,—a Pacific Coast Tern of the present day.

Fossils collected in the same locality as the last by Mr. Charles H. Sternberg.

Sterna fosteri?

This is a smaller species than the last, and in Professor Cope's collection I find two perfect coracoids, two carpo-metacarpi, and a humerus (imperfect) of a Tern, which, in the absence of more complete material, I provisionally refer to this species. They belonged to a larger bird than either *Sterna antillarum* or *Hydrochelidon nigra surinamensis* (Gmel.), and I have carefully compared them with skeletons of both those forms. In the avifauna of the present day, Foster's Tern has a general distribution over all North America.

Mr. Sternberg also collected these fossils in the Silver Lake region of Oregon.

Hydrochelidon nigra surinamensis.

A single humerus (not quite perfect) of this species is in Professor Cope's collection. I have compared it with the corresponding bone of a Black Tern belonging to the collections of the U. S. Museum (No. 17,688), and find it to agree so closely that there can be no doubt as to its identity. No other bones of this species were found.

Collected at Fossil Lake, Oregon, by C. H. Sternberg for Professor Cope.

I have reason to believe that other Gulls and Terns existed in the avifauna of the region under consideration during the later tertiary time, but the material in the collection is too fragmentary, beyond what has been given above, to make them out. The ground where they were discovered will well repay going over again.

The following is the list of the Longipennes as I have identified them above.

Larus argentatus smithsonianus.
Larus robustus sp. nov. (extinct.)
Larus californicus?
Larus oregonus sp. nov. (extinct.)
Larus philadelphia.
Xema sabinii.
Sterna elegans?
Sterna fosteri?
Hydrochelidon nigra surinamensis.

STEGANOPODES.

PHALACROCORAX MACROPUS.

This extinct Cormorant is the *Graculus macropus* of Cope, first described and characterized by him in the Bulletin of the U. S. Geological and Geographical Survey, Vol. IV, No. 2 (1878) pp. 386, 387.

The present collection contains the following bones:

1 Superior mandible (left lateral half.)
1 Ramus of mandible (right posterior half.)
3 Cervical vertebræ.
1 Dorsal vertebra.
1 Pelvis (imperfect.)
5 Coracoids (3 nearly perfect.)
1 Sternum (only the coracoidal grooves.)
1 Humerus (only the distal third, right limb.)
1 Ulna (only the proximal end, right limb.)
1 Radius (only the distal end, right limb.)
4 Carpo-metacarpi (imperfect, includes two in the Condon collection, one nearly perfect.)
1 Phalanx of index digit (proximal one, right limb.)
1 Femur (left side, imperfect.)
2 Tibio-tarsi (proximal and distal extremities only.)
10 Tarso-metatarsi (three from right limbs; seven from left limbs; one or two very nearly perfect; great variation in lengths.)

Mr. F. A. Lucas, in a paper entitled *Contribution to the History of Pallas' Cormorant*, gives us some useful osteological characters and measurements of the bones of various Cormorants, and from it I take the measurements of *P. carbo* given below to compare with *P. macropus*, the former being our largest species of existing North American Cormorant.

Phalacrocorax macropus belonged to the short heavy-billed group of Cormorants, or to the *Phalacrocorax* subgeneric division, and its powerful hooked, superior mandible exhibited a long concavity along the midlongitudinal line of the culmen. Its dentary margin was cultrate. Most of its skeleton was non-pneumatic.

MEASUREMENTS (IN MILLIMETRES) OF CORRESPONDING BONES OF PHALACROCORAX MACROPUS AND P. CARBO.

[All measurements are in a direct line and not along curves.]

VARIOUS BONES.	P. macropus Cope collection.	P. carbo Yale College Museum, No. 535.
Coracoid.		
Length	93	87
Femur.		
Length	75 (approx.)	70
Tarso-metatarsus.		
Length	87	72
Proximal transverse width	18	16
Distal width	20	18
Proximal phalanx, index digit.		
Length	21	not given
Greatest width	12	" "

The posterior end of the ramus of the mandible had characters that quite agree with *P. urile*, and that bone was strong and powerful. The superior lip of either coracoidal groove of the sternum presented the usual vertical, suboval facet for articulation with the coracoid, a more linear one being developed on the lower lip of the groove nearly opposite the first. It was by these characters that I was at once enabled to diagnose the small bit of the only sternum of *P. macropus* that was to be found in the collection. The sternal manubrium was rudimentary and lay in the plane of the carina.

All Cormorants vary greatly in size for the different ages, and to this *P. macropus* offered no exception. As I have shown above, its tarso-metatarsus measured in extreme length 87 millimetres; a small one in the Cope collection measures in extreme length but 75 millimetres. Fossil specimens of all subadult birds are pale gray in color and are characterized by having a roughish surface.

In the main the characters presented on the part of its skeleton agree with those Cormorants now retained in the subgenus *Phalacrocorax*, rather than with the *Urile* group.

Cope has said in the paper quoted above that "This species appears to have been common in the Pliocene of Oregon, where it was discovered by Charles H. Sternberg. * * * * * * * "With this bird, the extinct *G. idahensis* Marsh, nearly agrees in measurements, exceeding a little the corresponding parts of the living bird". [*P. dilophus*]. (p. 387).

PELECANUS ERYTHRORHYNCHOS?

There is in the Cope collection the distal end of the right ulna of a Pelecan, a perfect specimen. It belonged to a bird very slightly larger than *Pelecanus fuscus*, and I have carefully compared it with the corresponding part in that specimen and find it to agree almost exactly in its characters. (No. 18,483 Coll. U. S. National Museum). As *P. erythrorhynchos* is now abundant on Silver Lake, I have no doubt that its ancestors, as the same species, existed in the ancient avifauna of the tertiary epoch of that region.

Fossil specimen collected in same locality by Professor Cope.

The following *Steganopodes*, then, occurred or probably occurred in the Equus Beds of Oregon :—

Phalacrocorax macropus (numerous and now extinct.)
Pelecanus erythrorhynchos ?

ANSERES.

A great many species of existing forms of Swans, Geese, and Ducks at the present time resort annually to Silver Lake during the migrations, so we would naturally look for numerous species of the same group in a locality where fossil forms of birds so abundantly occur. In this there is no ground for disappointment, and in the collection now in hand the *Anseres* are well represented.

More or fewer of these are found to be identical with western species now existing, while several closely allied species have become extinct, and in one or two instances very different types have shared the same fate. It seems to be in the natural order of things that large bulky forms of any group of vertebrates sooner or later disappear from the face of the earth, but it still remains quite problematical why an average sized Duck, a good flyer, living on the same food as its immediate kin, and nothing peculiar about it, should, with more or less suddenness, so disappear. But that such cases have occurred, and are continually occurring, there is no doubt; to cite a well known instance one has but to mention the remarkable case of extinction exemplified in the Labrador duck (*Camptolaimus labradorius*). That bird, as is well known, quite suddenly became extinct upon our North Atlantic Coast, and, as it were, under the very eyes of all ornithologists. No adequate reason for its disappearance has yet been furnished. With this example before us, no one would at the present time experience any surprise were any other one of our common species of anserine fowl to disappear in the same manner. Having the history of *Camptolaimus* in my mind, when I came to study the fossil *Anseres* of the Silver Lake region I naturally looked for at least a number of species that had long since ceased to exist, and upon completing that study felt no small degree of surprise in finding so many fossil forms which, in so far as their osteology was concerned, appeared to be identical with those *Anseres* still in existence in our avifauna.

The following are the anserine species which have thus far been discovered in the Equus Beds of Oregon, and they are all represented in the present collection.

LOPHODYTES CUCULLATUS.

A humerus, a carpo-metacarpus, and four coracoids, all from the right side, have been selected to represent this Merganser. Upon comparison they are found to be identical in all particulars of character with the corresponding bones in a skeleton of *Lophodytes cucullatus* in the collection of the U. S. National Museum (No. 18,597). The fossil humerus is perfect, and all the other bones very nearly so. Length of humerus 70 millimetres; length of carpo-metacarpus 43 millimetres; extreme length of any one of the coracoids 47 millimetres.

Cope collection: Equus Beds of Oregon.

Anas boschas.

Two carpo-metacarpi and a radius, both from the left side of this species, together with the anterior moiety of a right scapula, agree exactly with the corresponding bones of a specimen of this Duck in the collections of the U. S. National Museum (No. 18,598). Length of carpo-metacarpus 5·9 millimetres; length of radius 7·4 millimetres. There were no fossil bones of the Mallard in the Condon material.

Cope collection: Equus Beds of Oregon.

Anas americana.

Fossil bones of the Baldpate are not abundant in the collection, but a right coracoid and a left tarso-metatarsus are identical in all their characters with the corresponding bones of an example of this Duck in the osteological collections of the U. S. National Museum (No. 18,599). Extreme length of coracoid 4·9 millimetres. The low bulky hypotarsus of the tarso-metatarsus is once perforated and twice grooved for tendons. Length 4·2 millimetres.

Cope collection: Equus Beds of Oregon.

Anas carolinensis.

Numerous fossil bones of the Green-winged Teal were discovered, and I compared a number of them with the corresponding bones of a skeleton of the species in my private collection. These consisted of five humeri, two perfect (left side), and three imperfect (right side), also three coracoids, two ulnæ, a carpo-metacarpus, and a tarso-metatarsus. They agree in their characters quite as closely as do the corresponding bones taken from two specimens of this Duck as it now exists, and compared together I am inclined to believe that the species was a numerous one in former times, or during the later tertiary period. Length of humerus 60 mm.; length of ulna 50 mm.; length of coracoid 35 mm.

There is a humerus of the Green-winged Teal in Professor Condon's collection. It is from the right limb of the individual to which it belonged.

Cope collection: Equus Beds of Oregon.

Anas discors.

A perfect humerus and other bones of the pectoral limb, together with several coracoids represent this Teal in the collection. The humerus is somewhat shorter than the same bone in a skeleton of the species in my private collection, an old female. The fossil humerus probably belonged to a subadult specimen of a female;

it is perceptibly larger than the humerus of an old male *A. carolinensis* referred to under that Duck (see *antea*). Its length is 62 millimetres.

All the characters agree with the corresponding ones in skeletons of the existing species.

Cope collection: Equus Beds of Oregon.

Anas cyanoptera?

Unfortunately I failed to secure a recent skeleton of the Cinnamon Teal for comparison. It is a very abundant Duck in many localities in the West, where in former times the writer has killed many of them. In the present collection I find four humeri (three perfect); seven ulnæ (six perfect); five carpo-metacarpi (two nearly perfect); four radii (perfect); three coracoids (perfect); an imperfect scapula; three femora (two perfect); two tibio-tarsi (imperfect); and two tarso-metatarsi (one nearly perfect) all of which belonged to a Teal Duck larger than *Anas discors*. Taking everything into consideration it would seem most probable that these fossil bones belonged to specimens of this species. Indeed, I am of the opinion that the three Teals now found in our avifauna, which have been enumerated above, existed during tertiary time (Pliocene) without much, if any material change in their structure.

Length of humerus 67 millimetres.

Length of ulna 60 millimetres.

Length of carpo-metacarpus 45 millimetres.

Other bones of proportionate lengths. The shafts of the humeri, relatively as well as actually much slenderer than in *A. discors*.

Cope collection: Equus Beds of Oregon.

Spatula clypeata.

The Shoveller is represented by numerous fossil bones in the collection, and upon comparison I find them to be identical with the corresponding ones as they occur in skeletons of that Duck in my own private collection. At the present time it is a very common species in many parts of the West.

Pliocene of Oregon (Silver and Fossil Lakes): Cope collection.

Dafila acuta.

Represented in the collection by a perfect humerus (right side), a pair of coracoids, and several scapulæ, the last more or less imperfect. The humerus of this, the Pintail Duck, is quite characteristic, and the fossil specimen in Professor Cope's collection agrees absolutely in all particulars with the right humerus of a specimen belonging to a skeleton of this species in the U. S. National Museum (No. 18,602), with which I have compared it. The shaft of the bone is of large calibre for its length and the several characters of the extremities are strongly developed. It is markedly pneumatic, and very light both in the fossil and recent specimens. The radial crest is thick and low, and a deep notch separates the humeral head from the ulnar crest. Length 87 millimetres.

At the present time this species is abundant in many parts of Oregon.

Cope collection : Equus Beds, Oregon.

Aix sponsa.

A perfect humerus, numerus coracoids, and several other bones represent this Duck in the collection. Upon comparison with a skeleton of the species in the U. S. National Museum (No. 18,612) they all agree very closely in their characters, and in all probability the *Aix* of the Pliocene was the same form of bird, in so far as its osteology was concerned, as we now have in our avifauna. Length of humerus 72 millimetres. Length of carpo-metacarpus 47 millimetres. The coracoid, somewhat compressed in the antero-posterior direction, measures in length 44 millimetres. The bones of the pectoral limb seem to be slightly slenderer than in fossil specimens, but it may be due to individual variation, and the skeleton of the existing species at my hand may have been taken from a robust bird.

Equus Beds of Oregon (Silver Lake) : Cope collection.

Aythya marila nearctica ?

I find in the collection a humerus, an ulna, and two coracoids which evidently belonged to an *Aythya*. They have been compared by me with a skeleton of the Canvasback Duck (*Aythya vallisneria*) ; also with a skeleton of a Redhead (*A. americana*) ; and also with *A. affinis* and *A. collaris*. The specimens are too small for *vallisneria* and *americana*, and too large for *affinis* or *collaris*. I have no skeleton of *A. marila nearctica*, but know it to be a larger bird than either *A. affinis* or *A. collaris*, and so for the present I refer the above named specimens to the American Scaup Duck. It is as well to remark that both the humerus and the coracoids appear to have belonged to a subadult individual, as they exhibit the peculiar gray tint and the very fine granulated appearance of the surface. Length of humerus 90 millimetres ; greatest breadth of proximal extremity 20 millimetres ; greatest breadth of distal end 12 millimetres. I am not inclined to regard this as an extinct species of *Aythya*.

Cope collection : Pliocene (Equus Beds of Silver Lake) ; Oregon.

Glaucionetta islandica.

This species was very abundant during the Pliocene in the Silver Lake Region : perhaps the most abundant Duck. Professor Cope's collection has in it 26 specimens of the humerus of *Glaucionetta islandica*, ten of which are as perfect as though just taken from recently killed individuals. There are also numerous other bones, but no part whatever of the trunk skeleton. All these fossil bones agree in the minutest details with the corresponding bones of specimens of the species as they exist to-day. To establish this fact, I compared them all carefully with skeletons of *Glaucionetta islandica* contained in my own private collection. Length of humerus 84 millimetres ; length of ulna 74 millimetres ; length of carpo-metacarpus 51 millimetres, (absolutely identical in fossil and existing species).

Cope collection : Equus Beds of Silver Lake, Oregon.

CLANGULA HYEMALIS.

Two ulnæ in Cope's collection belonged to this species. They correspond exactly with that bone as I find it in a specimen of the Long-tailed Duck in the collections of the U. S. National Museum (No. 18,810) and they differ from all the others at my command. Fossil ulna of *Clangula* stout and heavy; extremities rather strongly developed. Length 65 millimetres.

Cope collection: Pliocene of Oregon (Silver Lake).

I have not at my command skeletons of *Charitonetta albeola* nor *Histrionicus histrionicus*, and I think it likely that the first named species occurred on Silver Lake and its sister sheets of water during the later tertiary. There are four tarso-metatarsi in Cope's collection that belonged to Ducks evidently related to either *Glaucionetta* or *Charitonetta*; they may have belonged to Ducks long since extinct but in the absence of the skeletons of birds I have mentioned above, I prefer at present to pass them over to the non-identified material, and give some future observer an opportunity to compare them with the forms that the present writer lacks. There are a number of other bones of the *Anatidæ* that I could not identify quite to my satisfaction. These for the present I have also laid aside. I strongly suspect that both *Merganser serrator* and *americanus* occurred during Pliocene times on those lakes; they may, so far as I know of anything to the contrary, occur there to-day. *Anas strepera* and *Erismatura rubida* may also have figured in former times along with the other fossil forms we have been examining. I have not had specimens of this skeleton for comparison. Nothing at present leads me to believe that there were Ducks during the Pliocene in Oregon which have since become extinct, but there may have been, and no evidence on the subject has as yet come to light. My own idea is that the *Anatidæ*, at least, existed pretty much the same in those times as they do at the present day, and their descendants in our recent fauna exhibit but few, if any, marked structural departures from them. It is a great pity that there is such a total absence of the fossil anserine skulls, for that part of the skeleton would show changes, had any in reality existed, better than any other part of the economy.

ANSER CONDONI sp. nov

This Goose, now extinct, must have been nearly as large again as our common wild Canada Goose (*Branta canadensis*). Its remains are represented in Professor Cope's collection by a fractured os furcula and the parts of two others.

These I have most carefully compared with the furculæ of a number of our wild geese and swans of the genera *Chen*, *Anser*, *Branta*, *Dendrocygna* and *Olor*, and find that upon the whole the majority of its characters are most like such a goose as *Anser albifrons*.

The specimens consist of the lower arc of the furcula, a nearly complete upper limb of the left side, and good fragments of the corresponding part from one or two other individuals. As in some of our existing Geese, the os furcula of *A. condoni* was pneumatic, especially the superior limbs, and it is upon the *inner* side of the latter that the pneumatic fossæ are to be seen, with the openings at their bases leading downwards. Now in *Anser albifrons* the pneumatic holes are upon the outer aspect of the limbs of the os furcula, the reverse of the case in the Swans, including *Cygnus paloregonus* of Cope, with which I have compared them all. But either free extremity of the os furcula in *Cygnus paloregonus* is long and pointed, being narrow vertically, and thickened transversely as we approach the extremity. It also lacks the peculiar process upon its upper border, so characteristic of some Geese and nearly all Ducks. In the Swans, of course, the lower mesial portion of the os furcula is very much modified so as to allow of the passage of the trachea into the sternum. Nothing of that kind existed in *Anser condoni* where the lower mesial part of the os furcula is almost exactly as we find it in *Anser albifrons*. The upper free end of a clavicle in *A. condoni* also differs very much from that bone in the Swans, for it is inclined to be deep vertically, compressed transversely, bluntly pointed distally, and possessed the peculiar process seen in *A. albifrons* upon its superior border.

There were no other bones of *Anser condoni* in the collection, and I am inclined to believe that that ponderous goose must have been well nigh extinct, when the other anserine forms I have described above were flourishing in numbers.

	Anser condoni.	Branta canadensis.	Anser albifrons.	Olor buccinator.
Mid-vertical depth of mesial portion of os furcula given in millimetres	16	8	7	10

Our *Branta bernicla* is a foot less in total length than its congener *B. canadensis*, and *Anser condoni* must certainly have been twelve or fourteen inches longer than *Branta canadensis*.

I take pleasure in dedicating this extinct species to Professor Thomas Condon of the University of Oregon, the first naturalist who discovered and collected any of the remains of fossil birds in the Silver Lake Region of Oregon.

The specimens of the os furculæ of this goose are in Cope's collection: Equus Beds of Silver Lake, Oregon.

Branta hypsibatus.

This extinct Goose has already been described by Professor Cope, and I have examined the material upon which he distinguished it.[1]

Branta propinqua sp. nov.

In describing his collection Professor Cope speaks of having discovered a Goose that it contained, which upon comparison he found to come "near *nigricans*".[2] The fossil remains of the bird are well represented in the collection, and it proves to be a small, true Brant Goose closely allied to *nigricans*. For it I propose the above name.

[1]Cope, E. D. Bull. U. S. Geol. Surv. Terr. IV, No. 2, 1878, p. 387. See also *Branta hypsibates*, A. O. U. Code and Check List of N. A. Birds, 1886, p. 364. *Branta hypsibates* Coues MS. There was but one bone of this bird found, a tarso-metatarsus, and probably it was not an abundant species.

[2]*Ibid* p. 389.

	Millimetres.
Length of humerus	107
Length of ulna	95
Length of carpo-metacarpus	62
Length of femur	65
Length of tarso-metatarsus	75
Longitudinal mid-vertical axis of coracoid	52

The scapulæ agreed with those of *Branta*, and the left side of a specimen of its sternum showed it to possess seven facets upon that costal border. A sternum of *Branta canadensis* (No. 18,609 U. S. Nat. Mus.) has eight hæmapophysial facets upon either costal border. *B. propinqua* possessed an os furcula agreeing in form with that bone as now found among our Brant Geese. There is a specimen of it in the collection nearly perfect. Indeed all the bones of this species are in a beautiful state of preservation and many of them complete. Type bone is the humerus shown in fig. 17, Pl. XV.

Cope collection: Pliocene of Oregon. Silver Lake Region.

BRANTA CANADENSIS.

Numerous bones from various parts of the skeleton of the Canada Goose are to be found in the collection, some perfect, some more or less so, and some fragmentary. A study of these and comparisons with the corresponding bones of a recent skeleton of this Goose (No. 18,609 U. S. Nat. Mus.) convince me that the species of the Equus Beds are osteologically identical with the existing species, or in other words, the Canada Geese which thrived during the later tertiary time of the western part of our continent were similar to the Geese we now call *Branta canadensis* in our avifauna

The Swans and Geese of that ancient time seem to have suffered from a peculiar disease of the bones. It was confined to the superior angle of the pollex metacarpus of the carpo-metacarpus. It appeared to be of the nature of a small, tuberculated exfoliation of the bone at that point, and the evidences of it are to be seen in many of the carpo-metacarpi of those birds in the collection now under consideration.[1] Cope has already pointed out the fact that the remains of the Canada Goose occurred in the Equus Beds of Silver Lake (Bull. U. S. Geol. Surv. Terrs., 1878, IV, p. 389.)

Cope collection: Pliocene of Oregon (Silver and Fossil Lakes.)

ANSER ALBIFRONS GAMBELI.

Professor Cope has also pointed out the fact of the existence of this bird in the Equus Beds of Fossil and Silver Lakes, Oregon. (See Bull. U. S. Geol. Surv. Terrs. 1878, IV, p. 389.

The specimens are in his collection.

[1] In an illustrated article entitled "Notes on Palæopathology" accepted for publication by *The Popular Science Monthly*, of New York, I dwell quite fully upon this subject. R. W. S.

Chen hyperborea.

Judging from the fossil remains of this Goose in the collection, it, too, must have been nearly as abundant in the region as the Canada Goose. I have determined its existence there through a comparison of the specimens with bones of *Chen h. nivalis* (No. 18,611 of the U. S. Nat. Mus.) It was no doubt identically the same species as exists over the same range at the present time.

Equus Beds of Oregon: Specimens in the collection of Professor Cope.

CYGNINÆ.

Olor paloregonus.

This is the extinct Swan described by Professor Cope as *Cygnus paloregonus*, the description being based upon "four tarso-metatarsi, two of which are nearly perfect".[1] It was a species rather larger than *O. buccinator* and somewhat smaller than *O. columbianus*, that is judging from the above named bones. Apart from the skull and pelvis, its remains are represented in Cope's collection by many bones from a number of individuals. There are also several specimens in Professor Condon's collection, including a humerus, which unfortunately lacks a part of either extremity. Osteologically, it differed but little from existing Swans, being probably most closely affined to *Olor columbianus*. I have compared its bones with the corresponding ones belonging to a skeleton of *O. buccinator*, a specimen presented to me several years ago by Mr. G. Frean Morcom, of Chicago, and since placed by me in the U. S. National Museum (No. 18,509.)

Professor Cope's paper contains full measurements of the tarso-metatarsi of *Olor paloregonus* and to those I add the following, given in millimetres.

	Millimetres.
Length of humerus (restoration from two individuals)	290
Length of ulna	255
Length of carpo-metacarpus	141
Length of proximal phalanx of index digit	59
Length of femur	110
Length of coracoid (long axis)	97
Length of basal phalanx, mid.-anterior toe	67

"This Swan was discovered by Ex-Governor Whitaker, of Oregon, in the Pliocene formation of that State. The same bird was afterward procured by my assistant, Mr. C. H. Sternberg". (Cope.)

To recapitulate, my investigations go to show that the following anserine forms occurred in the Pliocene (Equus Beds) of Oregon:—

Lophodytes cucullatus.
Anas boschas.
Anas americana.

[1] *Ibidem.* pp. 388, 389.

Anas carolinensis.
Anas discors.
Anas cyanoptera?
Spatula clypeata.
Dafila acuta.
Aix sponsa.
Aythya marila nearctica?
Glaucionetta islandica.
Clangula hyemalis.
Anser condoni sp. nov.
Branta hypsibatus.
Branta propinqua sp. nov.
Branta canadensis.
Anser albifrons gambeli.
Chen hyperborea.
Olor paloregonus.

ODONTOGLOSSÆ.

PHŒNICOPTERUS COPEI sp. nov.

It is a fact of no little interest that a Flamingo inhabited the shores of the lakes of the Silver Lake region of Oregon during the Pliocene epoch. It was a bird closely allied to our existing *Phœnicopterus ruber*, and slightly larger than it. Fossil remains of the species, which belonged to two or more individuals, are in the collection of Professor Cope, and they consist of the following bones: a left *os quadratum* (nearly perfect), a right coracoid (very nearly perfect), a proximal phalanx of the index digit of the right pectoral limb (perfect), a right tibio-tarsus from a subadult individual (lacks the proximal end and outer condyle), a left tibio-tarsus from an adult individual (imperfect, has the distal end and *inner* side of the lower half of the shaft), a tarso-metatarsus from an adult individual, left pelvic limb (distal half only, perfect), a lower end of the same bone from another specimen (perfect as far as it goes), a basal phalanx of the mid-anterior toe of the left pelvic limb (adult, and perfect), and several other fragments of long bones, including a tarso-metatarsus of a very young bird.

I have compared all these bones with the corresponding ones from a skeleton of *Phœnicopterus ruber* and find that so far as the osteological characters are concerned they are substantially the same in the two species. The subjoined table presents some comparative measurements of the bones of these two Flamingoes, the existing and the extinct one. The measurements are in millimetres.

It will be observed from these measurements that the two species were nearly of a size, but were probably somewhat differently proportioned. Upon comparing the fragmentary shafts of the long bones of *P. copei* with those of the existing species I am convinced that the extinct form was longer winged and longer legged and toed than *P. ruber*. Some of the best distinguishing characters are seen in the coracoids of the two birds. While the sternal ends of these bones agree very well, their summits are different. In *P. ruber* this part is tuberous and broad transversely and a general concavity exists just below it upon the mesial aspect of the upper part of the shaft. In *P. copei* the summit is markedly narrower while the mesial aspect of the shaft just below it is a circumscribed, flat area. The scapular process in *P. ruber* is narrow in the vertical direction,—broader in *P. copei*. The distance from the anterior edge of the glenoid cavity to the anterior border of the shaft in *P. ruber* measures ten millimetres; in *P. copei* only eight millimetres. (See Figs. 41, 42, and 43, Pl. XV, also Figs. 28, 29, 38, Pl. XVII.)

In dedicating this species to Professor E. D. Cope of Philadelphia I feel that I pay but a very slight tribute to one who has done so much to advance the science of paleontology in America.

Phœnicopterus copei was discovered at Fossil Lake, in the Pliocene formation, Oregon, by Mr. C. H. Sternberg.

THE BONES.	P. ruber M.	P. copei M.
Greatest length of proximal phalanx of index digit (including distal process)	43	46
Greatest width of the same	10	10
Coracoid (longest diameter)	68	65
Coracoid greatest width, sternal end	35	35
Greatest width of distal end of tibio-tarsus	17	17
Antero-posterior diameter of inner condyle, tibio-tarsus	20	20
Greatest width of trochlear end of tarso-metatarsus	20	22
Length of basal phalanx, mid-anterior toe	47	48

HERODIONES.

ARDEA PALOCCIDENTALIS sp. nov.

Represented by the lower part of the shaft and distal trochleæ of the right tarso-metatarsus. This bone, from a medium-sized Heron, I have compared with the corresponding one in several of our smaller *Ardeidæ*, as *Ardea candidissima*, *A. cœrulea*, *A. virescens* and the Black-crowned Night Heron (*Nycticorax n. nævius*), and although it agrees very closely with most of them in its osteological characters, it agrees with none of them in point of size. It belonged to a Heron larger than *A. candidissima* and smaller than *A. egretta*, and I am of the opinion that the species is extinct. Transverse diameter of trochlear extremity equals eleven millimetres. (See Fig. 31, Pl. XVII.)

Cope collection: Pliocene of Oregon.

PALUDICOLÆ.[1]

FULICA AMERICANA.

Cope has already proven that the American Coot was represented in the

[1]In February last (1892), Professor Cope did me the honor of submitting to me for description the fossil bone of a bird from Texas. My description appeared in a paper published by himself and entitled, "A Con-

tertiary avifauna of Oregon,* and upon examination I find that it was probably the only paludicoline genus that did occur there. I was rather surprised not to find a *Grus*, or some Rails, but there is no evidence of them. On the other hand *Fulica* must have been a very abundant species judging from the long series of bones existing in the collection. Upon comparing them with the corresponding bones of a skeleton in my private cabinet, a *Fulica americana*, which I collected several years ago in New Mexico, I find them to agree in size and osteological characters. The same species existed then as now, and the ancient marshes of the Oregon lakes knew this bird quite as well as do all similar places throughout the United States at the present time.

Cope collection: Equus Beds of Oregon.

FULICA MINOR sp. nov.

Agreeing osteologically with the last but a much smaller species. Represented by a pair of humeri, a pair of coracoids, and a right femur, apparently from as many individuals as there are specimens. When first examined by me I was inclined to believe that the difference in size was merely sexual, but it is too great for that, and the sexes in *F. americana* agree in size. Moreover the bones of *Fulica minor* are not from subadult specimens, they exhibit all the evidence of having belonged to fully adult birds. They differ with the same bones in *Ionornis* and *Gallinula*. I make the following comparative measurements in millimetres. Type bone is a humerus shown in Pl. XVII, fig. 32.

	F. americana	*F. minor*
	M.	M.
Height of coracoid	32	27
Length of humerus	70	62
Length of femur	57	51

Cope collection: Pliocene of Oregon.

[illegible] the Vertebrate Paleontology of Texas", it constituting a contribution to the Proceedings of the [illegible] Society (Vol. XXX). Reprints of that paper were issued April 14, 1892. The fossil to [illegible] was therein described (pp. 125–127) and seemed to me to have belonged to some rail-like bird [illegible]. I originally proposed the name of *Ralloides* for a genus to contain it, giving it at the [illegible] specific name of *oshornii*. In a private note, dated Philadelphia, February 14, 1892, Professor [illegible] "Please make a new generic name, for 'Ralloides' is 'vox hybrida' (i. e. latin and greek) [illegible] for Rallus; will Creccoides or Creccopus answer?"

[illegible] any part of his valuable criticism and suggestion, I at once adopted the name [illegible] for my new genus, and as *Creccoides* it duly appeared in the Proceedings above mentioned. It [illegible] to send one of the reprints to my friend Professor Alfred Newton, F. R. S. the distinguished [illegible], who in a letter to me dated Magdalene College, Cambridge, England, 11 May, 1892, [illegible] you call your new genus of fossil birds *Creccoides*—I think you should have written [illegible] with one c only in the middle, for as you have it, it would signify *Crecca* for Teal-like —— and by the A. O. U. rules of nomenclature rectification is impossible! I flatter myself that some of us here are not [illegible]." In this place I desire to thank Professor Newton for having pointed out to me this error, and to say that I also flatter myself that I chance to be one "here", not bound "by the A. O. U. rules of [illegible]", and therefore hereby desire my new genus of fossil birds, considered in this note, to stand as [illegible] instead of "*Creccoides*" as it was originally printed in the Proc. Amer. Phil. Soc. for 1892 (p. 125).

R. W. S.

*[illegible]

LIMICOLÆ.

Phalaropus lobatus.

The Northern Phalarope is represented in Professor Cope's collection by three humeri all nearly perfect. Upon comparing them with the humerus belonging to a skeleton of this species in the U. S. National Museum (No. 13,638) I find the agreement substantially exact in all the characters and so conclude that this species also figured in the avifauna of the Pliocene of Oregon. Very likely there were other small limicoline birds represented, but their bones being small and light, they probably have, from time to time, been blown away by the wind when they worked up with the other fossils in the loose soil that formerly constituted the bottom of the lake. A number of the cosmopolitan *Tringeæ* no doubt frequented the ancient shores of those lakes, and it is to the probable fate of their remains that I refer.

The three humeri of this Phalarope were the only fossil bones of any of the *Limicolæ* discovered. Length of any one of the specimens is 29 millimetres. In the case of the Red Phalarope (*Crymophilus fulicarius*) the humerus is considerably larger than this, while in Wilson's Phalarope (*Phalaropus tricolor*) it is smaller. I have compared these fossil humeri with specimens of those bones as they occur in the majority of our existing western forms of *Tringeæ* and small Plovers, and they fail to agree with the characters of any of them. I was much pleased to find that the osteological characters of a single bone in so small a bird, could be used to so great advantage.

Equus Beds of Oregon : Cope collection.

GALLINÆ.

My private cabinet contains specimens of all the various species of existing United States *Gallinæ*, as well as skeletons of the wild *Gallus bankiva* of India, and other gallinaceous types, so that when I found the fossil remains of several species of this group in Professor Cope's material, I felt that I could make the most exhaustive comparisons between them and the existing species. This has been done, and the following forms of fowls flourished at Fossil Lake, or rather in that part of the country where Fossil Lake existed, during the Pliocene epoch.

Tympanuchus pallidicinctus.

A perfect humerus (right side) and several more or less imperfect ones, two coracoids (left), the upper third of a femur (right), and two carpo-metacarpi represent this Grouse. They are all identical with the corresponding bones as we find them in the existing species, and are interesting from the fact that they go to show that in former times the range of the smaller species of Prairie Hen was far more extensive than at the present day. During violent wind-storms probably some of these birds were blown into the Pliocene lakes and this would account for the discovery of their fossil skeletal remains being mixed up with those of the water birds. Perhaps, too, they were also dropped into the water by raptorial species.

Equus Beds, Oregon: Specimens all in the collection of Professor Cope.

PEDIOCÆTES PHASIANELLUS COLUMBIANUS.

A number of the bones of the limbs and a right coracoid, all more or less perfect, attest the presence of this species of Grouse in the same geological formation as the last, and I am of the opinion that both species were quite abundant during the later tertiary period of the west. Osteologically, these fossil bones cannot be distinguished from those of the existing species, of which latter I have several skeletons in my possession.

Cope collection: Equus Beds of Oregon.

PEDIOCÆTES LUCASI sp. nov.

An extinct, and at the same time a larger and heavier *Pediocætes* than any species of the genus now existing in our avifauna. Represented by three ulnæ, two tibio-tarsi, and a tarso-metatarsus,—some of the specimens being nearly perfect.

(MEASUREMENTS IN MILLIMETRES).

	P. p. columbianus	P. lucasi
Length of ulna	60	65
Length of tarso-metatarsus	42	44

As far as my material goes to show, the two species were in their osteological characters essentially the same, but the several bones compared are in *P. lucasi* markedly stouter with their extremities more powerfully developed. For instance the greatest transverse diameter of the distal end of the tarso-metatarsus in *P. p. columbianus* measures but 9 mm. while in *P. lucasi* the same diameter measures 11 mm, and this relative proportion is sustained for the ends of all the other long bones. The shaft of the tarso-metatarsus in the existing species is rather inclined to be slender,— in *P. lucasi* it is very perceptibly stouter and stronger. These differences were unquestionably extended to other parts of the skeleton of the extinct species, resulting in the considerably larger form which it undoubtedly was. Type a perfect right ulna, Pl. XVII, fig. 30.

I take pleasure in dedicating this species to Mr. F. A. Lucas of the Department of Comparative Anatomy of the U. S. National Museum, in recognition of his published labors in avian osteology, and his past and present Museum work, both in paleontology and avian osteology.

Equus Beds, Oregon: Cope collection.

PEDIOCÆTES NANUS sp. nov.

Differing osteologically with *P. p. columbianus* and *P. lucasi* only in the matter of size, this species was smaller than either. Possibly the three species intergraded at the time they co-existed, but the material now under consideration does not clearly indicate this. The limb-bones of the two extinct forms are in both *P. lucasi* and the present species stouter, with more strongly developed extremities than at present exist in *P. p. columbianus*, which would seem to point to *P. lucasi* and *nanus* being the more nearly affined forms. It is especially unfortunate that no skulls, sterna, or pelvis belonging to these species were discovered; they would have shed no little light upon the subject of their true kinship. The measurements are in millimetres.

	P. lucasi.	P. nanus.
Length of tarso-metatarsus	44	38
Greatest transverse diameter of proximal end	11	9
Greatest transverse diameter of trochlear extremity	11	10

Pediocætes nanus has proven to be the smallest species of the *Gallinæ* collected thus far in the Silver Lake region, and I found no fossil remains of either the Ptarmigans or the *Perdicinæ*. During my examination I made frequent comparisons with skeletons of the existing genera *Dendragapus* and *Bonasa*, two or three species of each being in my private collection. (Figs. 36 and 37, Pl. XVII.)

Pliocene of Oregon: Cope collection.

PALÆOTETRIX GILLI gen. et. sp. nov.

In that part of the collection which was made by Mr. Sternberg at Fossil Lake, I found the right carpo-metacarpus of a Grouse that was new to me. The specimen belonged to an adult individual, and in fossilizing has turned nearly pure white. In some instances the specimens that belong to the older forms of birds of this horizon exhibit that character, but it is by no means always the case. The specimen now being considered is nearly perfect, and evidently belonged to some tetraonine form that in point of size was smaller than an adult female *Centrocercus urophasianus*, and conspicuously larger than the largest of our other existing species of Grouse: *Tympanuchus* for example. This being the case it is unnecessary to compare it with any of the smaller Grouse or the Ptarmigans. Apart from the question of size then, it differs from *Centrocercus* in one very marked character, for we find that the articular surface at the summit of the bone on the outer side is continuous with that other articular surface found upon the outer aspect of the proximal end of the medius metacarpal. In *Palæotetrix* this is distinctly interrupted, and the first mentioned portion of the articular surface terminates posteriorly in a raised, rounded border. This latter character is most nearly approached by *Pediocætes*, and to a lesser degree by *Tympanuchus*, but is exactly alike in none of them. It is very probable indeed that such a well marked character as this was associated in the skeleton of *Palæotetrix* with excellent distinctive generic characters even stronger than it. More remains of the species, however, must be discovered before this question can be decided, and these no doubt will come to light in due time. I find the length of the carpo-metacarpus in *Centrocercus*, *Palæotetrix*, and *Tympanuchus* to be 50, 46, and 40 millimetres, respectively, the first named being chosen from an adult female. (See Fig. 35, Pl.

XVII). I am of the opinion that *Palæotetrix* belonged to an older genus of Grouse than any of our existing genera, and may have been well nigh extinct during the Pliocene epoch, and became utterly so before its close. When I first examined the specimen, it occurred to me that it may have belonged to some other kind of a tetraonine type, or to some of the existing species of Asiatic Pheasants, which, I argued, may have flourished during Pliocene times in that part of our continent which we now call Oregon. Upon comparison, however, with much of that kind of material I found nothing to support such a view. Nor did I find any Mexican or Central American types now in existence that possess such a carpo-metacarpus as did *Palæotetrix*. (Fig. 34, Pl. XVII).

I name this species in honor of my friend Doctor Theodore N. Gill, the distinguished American naturalist and ichthyologist.

So far as I know this is all the material that has been discovered up to the present time of this extinct Grouse, and it is the sole species of the genus, which I here create to contain it.

Equus Beds of Oregon: Cope collection.

The following is a list of species and genera thus far discovered in this horizon:

Tympanuchus pallidicinctus.
Pediocætes phasianellus columbianus.
Pediocætes lucasi sp. nov.
Pediocætes nanus sp. nov.
Palæotetrix gilli gen. et. sp. nov.

ACCIPITRES.

AQUILA PLIOGRYPS sp. nov.

Indicated by but one bone in the collection,—the basal phalanx of hallux digit of the right pelvic limb. After comparing it with the corresponding element as it occurs in the skeletons of all our existing North American Eagles and a number of foreign ones, I find that it does not agree with any, but belonged to a bird related to *Aquila chrysaetos*. As indicated by the bone under examination, however, the feet of this Eagle were more slender than they are in our Golden Eagle, and the joints merely a trifle longer. I am inclined to the opinion that this extinct Eagle was a size larger, though perhaps a slighter bird, than any of our now-existing United States Eagles.

MEASUREMENTS.

	mm.
Greatest length of the basal joint of hallux	38
Greatest diameter, proximal extremity	15
Transverse diameter, middle of the shaft	6
Transverse distance between the anterior trochlear borders	6

In general form it has all the characters of the podal joint as seen in the Eagles now with us, and the fossil specimen is perfect. Until more material is forthcoming I have thought best to retain this species in the genus *Aquila*, and have bestowed upon it the specific name of *pliogryps*, composed of *plio* from pliocene, and *gryps*, a griffin (Gr. γρύψ), convinced as I am that it was larger than a large Eagle, but from its more slender build, probably with habits more like a Falcon, in which case it no doubt stood among the most dreaded of the raptorial birds during the time it flourished. (Fig. 33, Pl. XVII).

Equus Beds of Oregon : Cope collection.

Aquila sodalis sp. nov.

This is another, and considerably smaller Eagle that co-existed with the last described one. Possibly it may have been the *Aquila danana* of Marsh, which he describes as "an extinct species of Eagle nearly as large as the modern Golden Eagle".[1] In the present collection it is represented by the proximal fourth of the left tarso-metatarsus, more or less imperfect. (See Fig. 33, Pl. XVII). Marsh's specimen of *A. danana* is described by him from the "distal portion of a left tibia", with "width of condyles in front" equal to eight lines. Now the greatest transverse width of the proximal end of the specimen in my hands also measures eight lines, or perhaps rather less. From this I am inclined to think that *A. sodalis* was perhaps a smaller bird than *danana*, and somewhat smaller than either the Golden or White-headed Eagles. There is also in the collection the mesial third of an *os furcula* of a medium sized Eagle, and it also very likely belonged to an individual of the present species. Its characters are quite like the characters of that part of the *os furcula* in any of the typical modern Eagles. In this connection I would say that there may be considerable specific variation in the form of the *os furcula* in any of the existing species of this group of the *Accipitres*. *A. danana* was discovered in the Pliocene of Nebraska.

A. sodalis had in the proximal moiety of its tarso-metatarsus all the usual characters found in the present representatives of the genus *Aquila*. The tubercle for the insertion of the tendon of the tibialis anticus muscles is strongly pronounced, being rather to the outer side of the longitudinal mid-groove on the anterior aspect of the bone. This tubercle is eight millimetres long, and situated a little less than five millimetres below the two antero-posterior perforating foramina found between it and the head of the bone. The inner one of these foramina appears behind, just at the lower point of commencement of the inner and larger process of the hypo-tarsus. In this last character it agrees with a specimen of *H. leucocephalus* at my hand. There is not sufficient material at my command to decide whether the posterior points of emergence of these foramina in the Eagles is constant or otherwise.

To be of the best service our large Museums should have at least seven or eight skeletons of each species of our United States Eagles, and then the paleonto-

[1]Marsh, O. C., *Am. Jour. Sci.* II, 1871, p. 125.

logical collections belonging to the Government, *after* they have been duly described by the person authorized to furnish science with their description, should be placed where the student in paleontology can have access to them, and not stored in private museums, where every application to simply compare such specimens with new incoming material may be completely ignored by their custodian.

There were at least two Eagles then, and perhaps others, that were represented in the avifauna of the later tertiary period of Oregon,—a large one, larger than our modern ones, and not so heavily proportioned (*A. pliogryps*), and a lesser one, a small buteonine Eagle, having perhaps both affinities with *Aquila chrysaetos* and *Haliaetus leucocephalus*, but more closely allined with the former (*A. sodalis*).

Cope collection: Equus Beds, Oregon.

STRIGES.

BUBO VIRGINIANUS.

I find the Great Horned Owl represented by an almost perfect left carpo-metacarpus and a toe-joint. The former is identical in character in all particulars, with the corresponding bone in a skeleton of *B. v. subarcticus* with which I have compared it. The limb bones in *B. v. subarcticus* are a shade less stout in their proportions than they are in *B. virginianus*, a fact I have satisfied myself about by comparing a number of the skeletons of both forms.

This fossil, however, may have belonged to an individual of some one of the other subspecific ancestral stocks, for three well-marked ones are now easily to be recognized. They are *B. v. subarcticus*, *B. v. arcticus*, and *B. v. saturatus*. At the present day *B. virginianus* ranges west only to the Mississippi Valley.

Cope collection: Pliocene of Oregon.

PASSERES.

SCOLECOPHAGUS AFFINIS sp. nov.

A Blackbird of this genus represented by two humeri (left), a coracoid (left), and three ulnae (right). All these bones are in a beautiful state of preservation and very nearly perfect, quite so in the case of most of them. Their osteological characters are identical with *Scolecophagus cyanocephalus*, and the long bones have about the same length, being but very slightly slender more in the calibre of their shafts. *S. affinis* was a somewhat larger species than *S. carolinus*, and probably a less robust bird than *S. cyanocephalus*. No other fossil bones of small passerine birds were discovered in the Silver Lake Region, and this Blackbird was probably a frequenter, in large flocks, of the shores of those ancient lakes. It is not unreasonable to suppose that some parts of the shores were marshy, and supported sedgy or reedy growths, and they afforded resorts in which a species of this kind would naturally delight. Our Red-winged Marsh Blackbirds (*Agelaius*), have similar habits to-day and I have frequently seen *S. cyanocephalus* in the marshes in the West.

In determining this species I compared its fossil bones most carefully with the corresponding ones in skeletons of representatives of the genera *Sialia*, *Hesperocichla*, *Merula*, *Turdus*, *Myadestes*, *Campylorhynchus*, *Harporhynchus*, *Mimus*, *Oroscoptes*, *Lanius*, *Ampelis*, all our large conirostral species, western and otherwise; all the medium sized *Icteridæ*; *Otocoris*; and specimens of the species of western *Tyrannidæ*. It agrees alone, in all characters, with the genus in which I have placed it. My own cabinet afforded the above material. (See Fig. 10, Pl. XV).

Specimens of fossils all in Professor Cope's collection: Equus Beds, Silver Lake Region, Oregon.

Corvus annectens sp. nov.

Recognized through the discovery of a right tarso-metatarsus, perfect with the exception of the loss of the inner articular facet at the summit. Having exactly the same characters as the corresponding bone from a skeleton of *Corvus corax sinuatus*, it nevertheless belonged to a species a full size smaller. Ravens of the present day vary much in size, the smaller forms being found in the southwestern parts of the United States, and the largest specimens in Alaska, while between these two limits the intermediate sizes gradually approach each other. The skeleton I have for comparison in the present instance is from a female I shot in New Mexico, and probably represents the minimum size of the modern bird; *Corvus annectens* is very perceptibly smaller than it, as may be seen by the following measurements in millimetres.

	C. c. sinuatus.	C. annectens.
Length of tarso-metatarsus	64	61
Transverse diameter, mid-shaft	5	4
Transverse diameter, trochlear end	9	8
Height of hypotarsus	6	4

In the absence of other material it would appear that the smallest American Ravens are the extinct forms, and that the species has increased in size since the Pliocene epoch, especially the boreal branch of the original stock. The gradation appears to be almost perfect, yet it would seem that between the present extinct species, and the largest Alaskan forms, there exist good specific differences. (See Figs. 14, 15 and 16, Pl. XV).

Cope collection: Pliocene of Oregon.

CONCLUSIONS.

To briefly recapitulate the events in the geological history of the continent west of the Mississippi River that led up to the epoch which has engaged our attention in the present memoir, it will be remembered that during the cretaceous times a great, shallow sea of broad expanse covered the entire central part of the now United States, forming an eastern and western continent. General and slow upheaval of the land towards the close of that period, gradually obliterated that sea, and the valley of the Mississippi appeared and the coast ranges of the Pacific were joined with the Appalachian chain by land. The last scenes in those changes were still being enacted during the Eocene, when to the eastward of the Mississippi River the continent was drying up, while to the westward, in the great Plateau Region, enormous fresh water lakes were being formed. Chief among them were those great sheets of water found both north and south of the Uintah Mountains; but the ones that interest us most here are those that gradually formed in Oregon. Following subsequent changes that took place in the tertiary, the latter finally constituted the lakes of the Silver Lake system, and their present position has been indicated in the foregoing paragraphs. To pursue the history, we know that the Plateau region towards the close of the Eocene, was again slowly upheaved, which again caused the drainage of all the Eocene lakes, while the remainder of the territory was slowly depressed, thus creating once more enormous Miocene lakes where the inland cretaceous sea formerly existed. Then followed the formation of the Coast range of mountains caused by the crushed up, complicated upfolding of the ancient sea-bottom of the then Pacific Ocean,—the long land-wrinkle thus produced finally remaining as the aforesaid mountain range. Once more the region of the Plains was depressed, extending the great Pliocene lakes already existing, and bringing about other remarkable changes. As the time for the Quaternary period approached, or in the later tertiary time, slow upheaval of the continent again took place, and obliteration of the lake systems over much of the area we have been considering was inaugurated. *Pari passu* with these scenic topographical changes were the gradual evolutionary ones that took place in the various faunæ of the tertiary as a whole. The vertebrate series approached more and more closely its character as we are now enabled to study it in recent times. Large and cumbersome forms in all the various classes, in many instances poorly suited to their several environments, or their environments as a whole, were slowly disappearing through extinction,—while others, perhaps of more pliable organization, lingered along through Eocene and Miocene time, to finally perish in the Pliocene.

Through the previous labors of Professor Cope, and from what we have been enabled to bring out in the present paper, one can, I think, succeed in picturing to the mind what must have been a daily scene, during certain seasons, at one of those ancient lakes, long since dried up, as, for instance, the old Oregonian Fossil Lake of Pliocene time.

We must believe that it still remains quite problematical whether man was known there, and further comparative research is demanded to decide whence came, and at what time, those stone implements of human manufacture, commingled as they are with the bones of the animals, many of which are long since extinct, found in the former bottom of the lake. But that the Mammoth (*E. primigenius*) came from time to time to the shores of that ancient lake there can be no question.

They probably resorted there for the same purposes as modern elephants now come to certain drinking-pools in their haunts in Africa. Mammoths among the large mammalia were not there alone, however, for at least four kinds of Llamas were associated with them in that fauna, and one species at least of these was as large as a camel, and the others not very much less. Horses of several varieties also resorted to those shores, and it is quite within range of possibility that at certain times one might have seen Mammoths, Llamas and Horses all there together, but in what force they came we now have no means of knowing. Modern Horses and Elephants often associate in their respective regions in great troops, and the habits of our recently extirpated Buffalo are well known. Yet, with respect to the latter, how scanty are their remains at their former drinking places. It is quite possible that the Horses of the Pliocene were equally abundant, and had habits not so very widely different. There was another remarkable mammal that occasionally figured in this Pliocene picture,—a great Sloth, which was fully as large as our existing grizzly Bear; and there is evidence that Bears likewise were to be seen there. Of the smallest carnivora and of small rodents there was no lack, for as we have seen, their abundant remains are to be found to-day in what was the former lake's bottom. There were Otters there, and Beavers, and no end of Hares, Gophers and their kin. Coyotes and perhaps other *Canidæ* were there to prey upon these, and they no doubt occasionally attacked the larger mammalia, especially the Llamas.

Passing to the bird-life, which we now know was very abundant, the scene would not be so very dissimilar, in so far as it was concerned, from what we might observe upon any of the large alkaline lakes of the west resorted to at the present day by the wild-fowl during their migrations. Great flocks of Swans, Geese and Ducks were there, feeding on the marshy shores of the lake or disporting themselves upon its waters. With but few exceptions they were of modern genera and species. A ponderous Goose appeared among them, perhaps but sparingly during Pliocene time, for it must then have been nearly extinct. And a Swan too, whose race has since died out was also there, but it was of a size quite in keeping with present day Swans. Several species of Grebe swam upon, and dived in those ancient waters; they were all like our existing Grebes, and most probably had similar habits. To these groups we must add many individuals of a species of a great, strange Cormorant (*P. macropus*), larger than any of our existing Cormorants, though probably, too, with habits not unlike them. Gulls and Terns in numbers were in the air, and doubtless files of Pelicans along the shore lines. But the strangest figure upon the scene among the birds was a true Flamingo. It could not have been very abundant for it has left but scanty remains. Still it was there, and its presence has its meaning,—it may even suggest ideas as to what the climate may have been in those times. Herons were to be seen, and in the marshes cackled Coots and flew flocks of Blackbirds, no doubt with notes and habits very similar to those of their descendants of the present day. *Tringeæ* and Phalaropes coursed along the low shores of the lake's margin, while upon its more rugged borders may have been seen Ravens perching, or even some representative of the Raptorial group. Further back from the lake's limits we would meet with several species of Grouse, and these were perhaps occasionally preyed upon by the falcon-like Eagle and its companion, the lesser form, which may have been seen circling in the air overhead. Doubtless those eagles chiefly subsisted upon the Hares and other smaller mammalia, as they do in certain regions now-a-days.

As the day closed, and night came on, its stillness no doubt was broken by the hoot of a Pliocene *Bubo*, in no important respect differing with his bubonine descendants of this psychozoic era.

There appeared to be no large or even medium-sized Reptilia, while the fish of the lake, although numerous, were limited in the matter of species. Many of the various groups and classes among the Invertebrata were doubtless present in great abundance, and when of suitable kind afforded an inexhaustible supply of food for the wild-fowl.

To speak again of the climate, it might well be compared with the present climate of Florida and the lower part of Louisiana, with the vegetation fully as luxuriant as it is now in those parts and with the Palms more abundantly represented.

Taken as a whole then, of the various vertebrates in the scene of a Pliocene lake in the region we have under consideration, we would be most naturally struck by the conspicuous difference seen in the mammalia. Although the majority of these are of existing genera, they now only occur in widely different parts of the world. Apart from one or two striking species, it would probably take the eye of an ornithologist to detect any marked departure among the birds. The large Goose, the Flamingoes, and the great Cormorant might be recognized by popular eyes. To the general naturalist, no doubt, the birds would offer the most attractive objects for study—for birds had feathers and peculiar *colorations* of bills and feet, and those characters may have changed considerably since the Pliocene epoch. Such secondary characteristics of external structures are far more liable to change through the influence of climate and surroundings reacting upon habits, than is the more essential part of the skeleton,—and we have but fossil bones before us. As I have pointed out in the body of my memoir, in the case of the majority of the bones, where the species, fossil and existing, have proved to be identical there have been no discoverable changes whatever in the topographical characters of the bones of existing birds as compared with those of their fossil ancestors. With respect to the fossil Grebes, I carefully examined by the aid of a lens the dentary margins of the mandibles of the species, but no vestigial evidences were to be seen, that might in any way indicate that their ancestors were the possessors of teeth in their jaws. Unfortunately the fossil pygopodous pelves were all broken so that their lateral parts were past all recognition. It would have been interesting to have compared the depths of the ilio-ischiac notch upon the posterior borders of those pelves with the same indentation as it now occurs in the corresponding species of the existing avifauna.

The writer entertains the idea that not only were ancient Divers, such as *Hesperornis*, or ancient larine types, such as *Ichthyornis*, possessed of teeth and a permanent posterior separation of the ilia, ischia, and pubic styles, but that the ancestors of a good many of our existing groups of birds enjoyed the same characters in their skeletons. That is to say could we trace back by means of fossil remains the present day Cormorants, or Anseres, or Accipitres and Striges, or perhaps even representatives of still higher groups, we would, sooner or later, meet with forms in the lines of their ancestry wherein the skeletal characters named above would obtain. Not that all would have them, but that many might. Some modern Ostrich-forms have the individualization of the pelvic bones posteriorly, yet they have no teeth in their jaws. Still the ancestors of *Tinamus* or the Emeu may have possessed teeth which have been lost in their descendants while the pelvic characters were retained. Surely all very early birds lacked a keel to the sternum sooner or later. Now *Icthyornis* is assuredly a very early avian type, but *Icthyornis* is a bird, notwithstanding it has teeth and vertebræ with icthyic characters. Could we but find the line of fossil ancestral remains of that genus, we must believe that in the still earlier forms, after they became really more avian than reptilian, their sterna lacked the carina, a feature it did not attain until feathers and flight were possessed, or were developed *pari passu* with them. There are those who believe that *Archæopteryx* had a keelless sternum, and no one doubts that it was a fair flyer for short distances. We very much need more material in the way of fossil birds, both land-birds and water-birds, from the geological horizons prior to the Cenozoic era. We cannot hope for much more light on the subject until such material is obtained.

The study of the material upon which the present memoir is based still further establishes the fact that the birds of the later tertiary time were simply the direct ancestors of existing genera and species of birds, from which in the majority of instances they, osteologically at least, scarcely departed at all. Disregarding for the moment those that became extinct during the Pliocene or early Quaternary, we may say in other words, that the remainder are essentially identical with the Psychozoic species they represent. As to the extinct forms, what they teach is not always clear. We may never know, for example, the reason for a large, powerful Cormorant passing completely off the scene and becoming extinct. It is not at all likely that any of the small and existing Cormorants are its descendants. It is easier to comprehend why a tertiary Flamingo should perish, as its habitat was slowly transformed into a desert region, but it will not throw much light upon the disappearance of a Swan, the latter no larger or smaller than its congeners upon either hand. In some cases the descendants are larger and more powerful than their Pliocenic ancestors, and this may apply to the Ravens. A small *Fulica* may have died out in the ordinary struggle for existence of its species, while its larger congener, more plastic or better suited to the subsequent geological changes, was destined to pass down its kind into futurity. For the extinction of small Gulls, Grouse and the like, we have, in the light of our present knowledge, no explanation to offer towards the solution of such, if I may be permitted to coin the word, camptolaimic problems. No doubt many birds existed in the Silver Lake Region of Oregon during the Pliocene, the fossil remains of which have as yet not been discovered. Fifty species are enumerated or described in the present memoir, and this would indicate that the avifauna of the region was far richer in forms then than it is at the present day. Changes in climate, topography,—and secondarily, changes in vegetation, have no doubt contributed to the production of such a result.

EXPLANATION OF PLATES.

[All the figures in the Plates were drawn by the author from the specimens, and are of natural size in each case].

PLATE XV.

FIG. 1. Direct mesial aspect of left coracoid of *Larus robustus*. (Cope collection).

FIG. 2. Direct anterior aspect of the left coracoid of *Larus robustus*. Same bone as shown in Figure 1, with the "costal process" restored in dotted line in each case.

FIG. 3. Anconal aspect of left humerus of *Larus oregonus*; distal extremity indicated by dotted line, by the assistance of the corresponding bone from a skeleton of *Larus delawarensis*.

FIG. 4. Anconal aspect of left humerus of *Larus delawarensis*, showing the obliquity of the osseous partition in the *fossa pneumaticus*, as compared with the same structure seen in *L. oregonus* (fig. 3). (Author's collection).

FIG. 5. Anterior aspect of the proximal fourth of the left tarso-metatarsus of *Aquila sodalis*. (Cope collection).

FIG. 6. Direct anterior view of a specimen of the right coracoid of *Phalacrocorax macropus*. Imperfect part restored from the corresponding bone from a skeleton of *Phalacrocorax dilophus*.

FIG. 7. Anterior view of a left tarso-metatarsus of *Phalacrocorax macropus*.

FIG. 8. Direct outer view of a left tarso-metatarsus of *Phalacrocorax macropus*. Same specimen as is shown in Figure 7.

FIG. 9. Left lateral view of the superior osseous mandible, and the hinder part of the mandible of *Phalacrocorax macropus*. These fragments may or may not be from the same individual. The remainder of the skull simply indicated, unshaded, by the assistance of a skull of *Phalacrocorax dilophus*.

FIG. 10. Anconal aspect of the left humerus of a specimen of *Scolecophagus affinis*.

FIG. 11. Anterior view of the right coracoid of *Phœnicopterus copei*.

FIG. 12. Anterior view of the right coracoid of a specimen of *Phœnicopterus ruber* (No. 18,494 U. S. Nat. Mus.); selected for comparison with the bone shown in Figure 11.

FIG. 13. Anconal aspect of the proximal phalanx of the index digit of the right pectoral limb of a specimen of *Phœnicopterus copei*. (Type: Cope collection).

FIG. 14. Direct superior view of the proximal extremity of the right tarso-metatarsus of *Corvus annectens* the same bone shown in Figure 16, designed simply to show the arrangement of the foramina for the passage of tendons. They agree with the Ravens of the present day.

FIG. 15. Anterior view of the distal end of the bone shown in Figure 16, illustrating the trochleæ.

FIG. 16. Outer aspect of the right tarso-metatarsus of *Corvus annectens*.

FIG. 17. Anconal aspect of a right humerus of a specimen of *Branta propinqua*.

Plate XVI.

Fig. 18. Inner aspect of the upper part of the *right* side of the *os furcula* of *Olor paloregonus*. This piece, here correctly figured, is the same that did duty for the *left* side in Figure 25. This fragment is in the possession of Professor Cope.

Fig. 19. Inner aspect of the upper part of the *right* side of the *os furcula* of *Anser condoni*. This piece is the same that did duty for the left side in Figure 26. Dotted lines restore its apex as before (Fig. 26). Cope collection.

Fig. 20. Upper view of the bent, posteriorly projecting part of the mesial portion of the *os furcula* of *Olor buccinator* (18,509 U. S. Nat. Mus.) Compare with Fig. 21.

Fig. 21. Upper view of the bent, posteriorly projecting part of the mesial portion of the *os furcula* of *Olor paloregonus*. Imperfect part restored in dotted line from the opposite side or perfect portion of the fragment. This is the same specimen which figures in the lower part of Figure 25.

Fig. 22. Outer view of the left side of the *os furcula* of *Anser albifrons* (Spec. 18,610 Coll. U. S. Nat. Mus.) Presented for comparison with Figure 26.

Fig. 23. Posterior aspect of the lower mesial portion of the *os furcula* of *Anser albifrons*. From the same bone shown in Figure 22. Presented for comparison with Figure 27.

Fig. 24. Outer aspect of the left side of the *os furcula* of *Olor buccinator* (Spec. 18,509, Coll. U. S. Nat. Museum).

Fig. 25. Outer aspect of the left side of the *os furcula* of *Olor paloregonus* (Coll. of Cope). Imperfect part restored in dotted line from the bone shown in Figure 24. The external characters, as the pneumatic foramen, etc. were obtained from the inner aspect of this same fragment in order to present the same view of it as is shown for *Olor buccinator* in Figure 24. The real aspect of this part is given in Figure 18.

Fig. 26. Outer aspect of the left side of the *os furcula* of *Anser condoni*, (Coll. of Cope). Imperfect part restored in dotted line from a specimen of *Anser albifrons* (Spec. 18,610 Coll. U. S. Nat. Mus.) The internal characters, as the pneumatic foramen, etc., were obtained from the inner aspect of this same fragment in order to present the same view of it as is shown for the specimens given in Figures 24, 25 and 22. The real aspect of this part is shown in Figure 19.

Fig. 27. Posterior aspect of the lower mesial portion of the *os furcula* of *Anser condoni*. Same fragment as is shown in Figure 26.

Plate XVII.

Fig. 28. Anterior view of the right tibio-tarsus of a subadult specimen of *Phœnicopterus copei*. About the distal two thirds.

Fig. 29. Anterior view of the left tibio-tarsus of an adult specimen of *Phœnicopterus copei*. Distal portion. Fragmentary.

Fig. 30. Anconal aspect of right ulna of *Pediocœtes lucasi*.

Fig. 31. Anterior aspect of the lower part of the shaft and distal trochleæ of a right tarso-metatarsus of *Ardea paloccidentalis*. Upper part of the bone simply indicated in dotted lines, the restoration having been made by the assistance and use of corresponding bones in the skeletons of several of the smaller United States Herons.

Fig. 32. Anconal aspect of a specimen of the left humerus of *Fulica minor*.

Fig. 33. Superior aspect of the basal phalanx of hallux digit of the right pelvic limb of a specimen of *Aquila pliogryps*. Type: Cope collection.

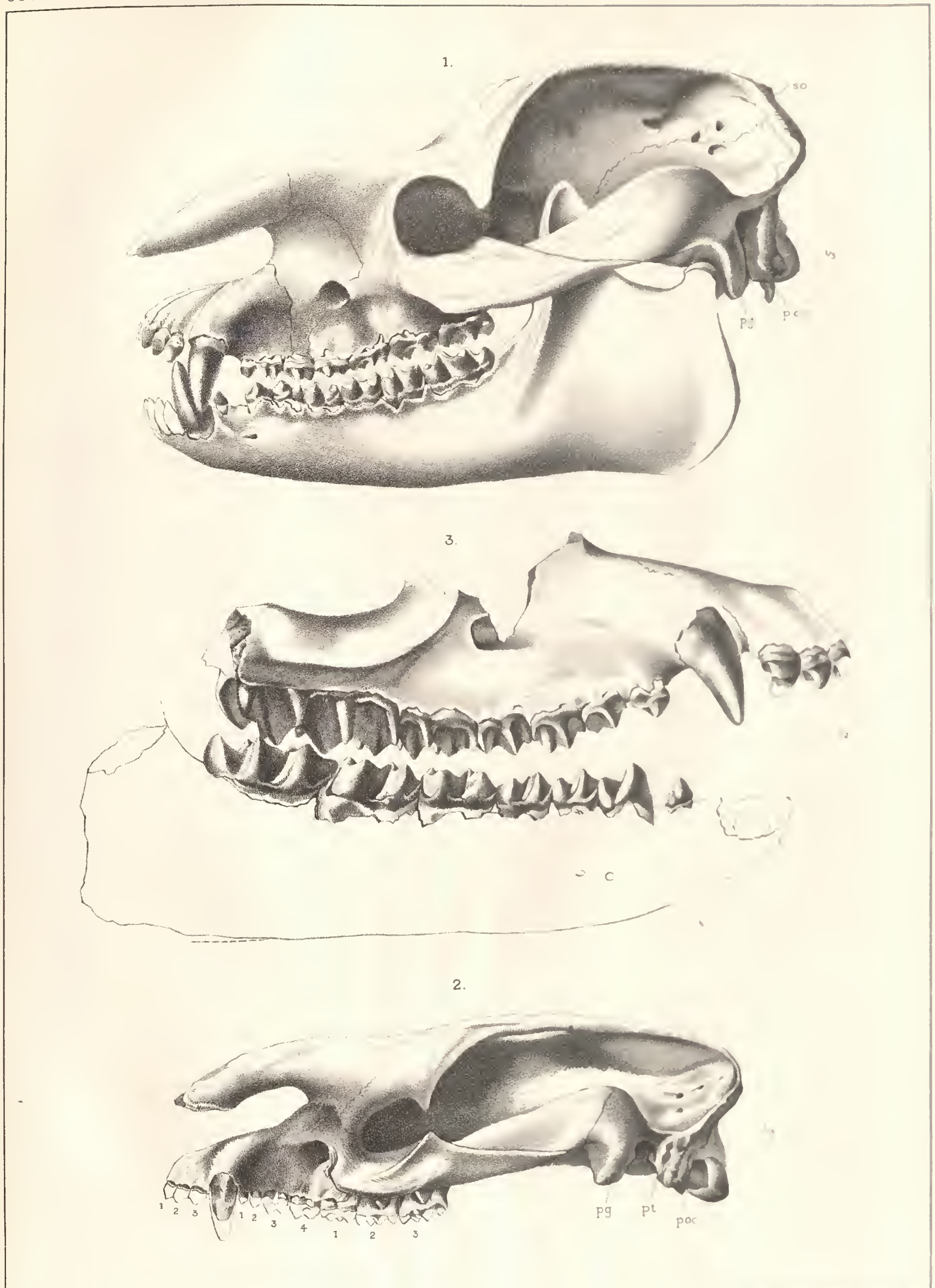
Fig. 34. Palmar aspect of the right carpo-metacarpus of *Palæotetrix gilli*. Imperfect portion in dotted lines, and restored by the use of the corresponding bone as it occurs in nearly all *Tetraonidæ*.

Fig. 35. Palmar aspect of the right carpo-metacarpus of a specimen of *Centrocercus urophasianus*. From a skeleton of a small female in the author's collection. Introduced for comparison with the type given in Figure 34, from the Cope collection.

Fig. 36. Anterior view of left tarso-metatarsus of *Pediocœtes nanus*.

Fig. 37. Palmar aspect of left carpo-metacarpus of *Pediocœtes nanus*: Probably a different individual.

Fig. 38. Anterior view of a left tarso-metatarsus of *Phœnicopterus copei*. Distal portion. Adult individual. (Type: Cope collection).



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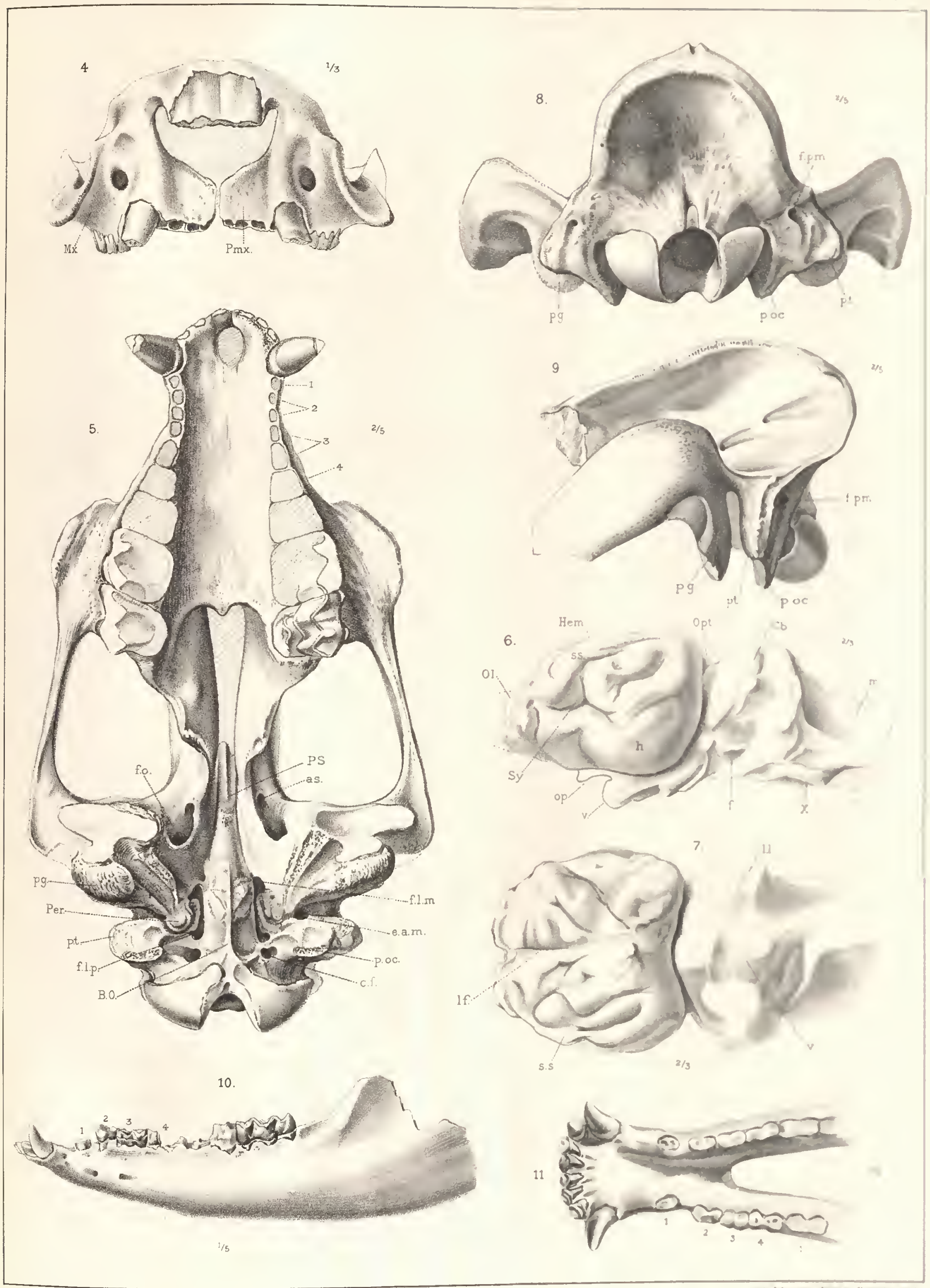
1. PALAEOSYOPS PALUDOSUS. 2. P. MEGARHINUS. 3. TELMATOTHERIUM CULTRIDENS



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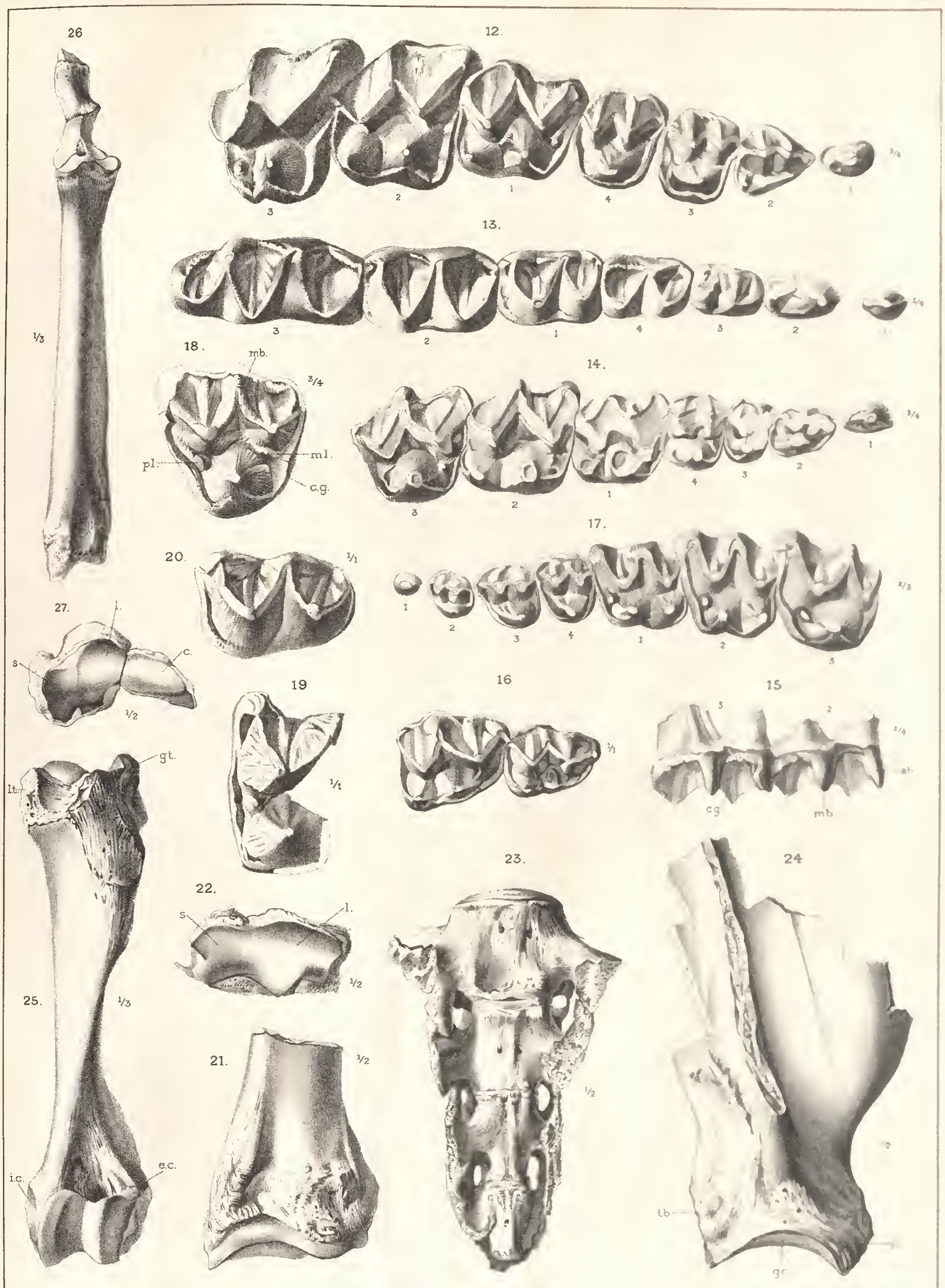
4-7. PALAEOSYOPS MEGARHINUS 8,9. LIMNOHYOPS LATICEPS 10,11 TELMATOTHERIUM HYOGNATHUS



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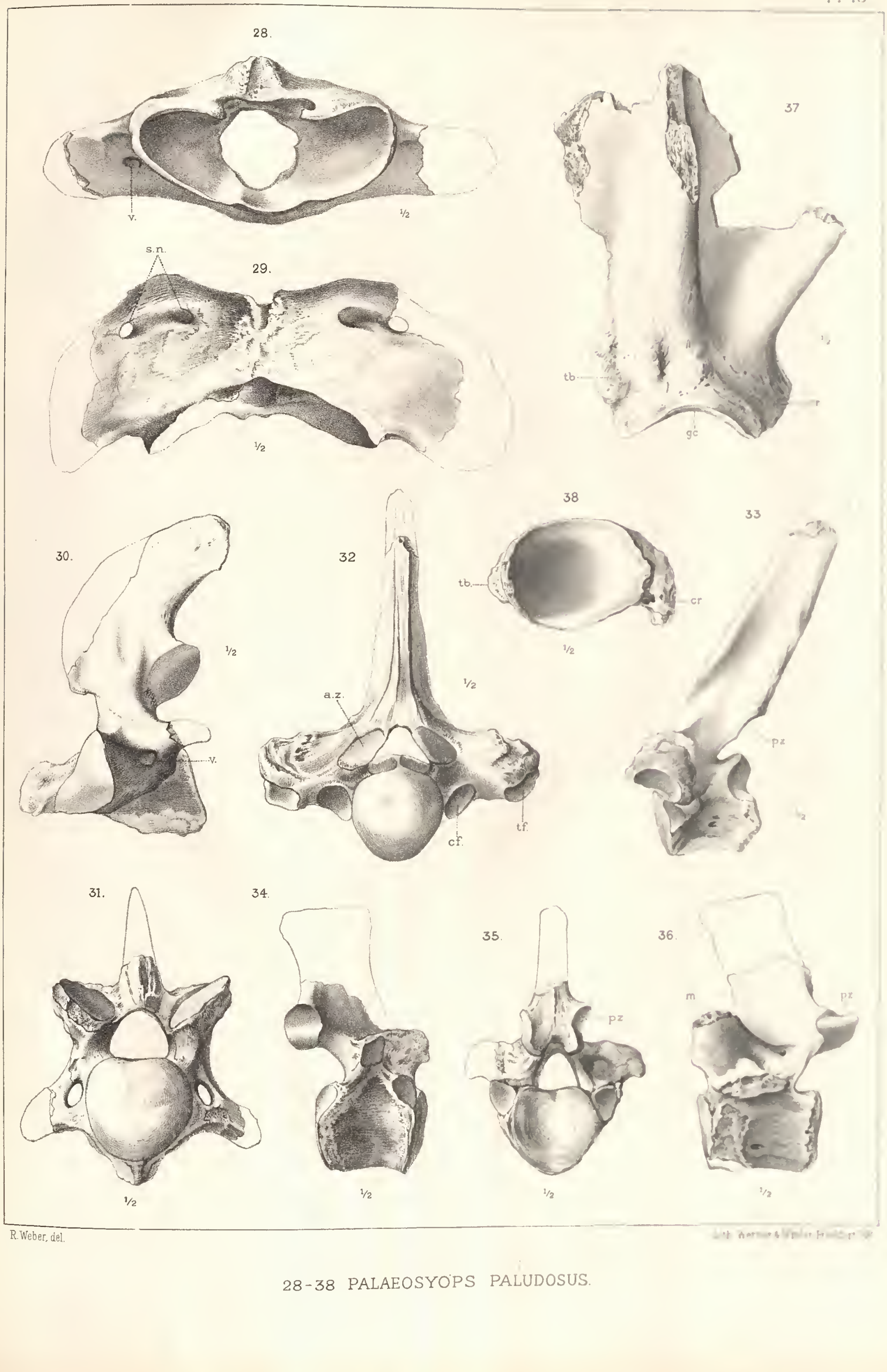
12, 13 TELMATOTHERIUM CULTRIDENS 14-16 PALAEOSYOPS MINOR. 17-23 P. PALUDOSUS 24-27 LIMNOHYOPS LATICEPS.



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28-38 PALAEOSYOPS PALUDOSUS.

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October, 1892.

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NEW AND LITTLE KNOWN PALEOZOIC AND MESOZOIC FISHES.

By E. D. Cope.

ELASMOBRANCHII.

Genus SYMMORIUM Cope.

Symmorium reniforme Cope, Amer. Naturalist, 1893, p. 999. Plate XVIII, Figs. 1-5.

Char. gen. Dentition as in *Cladodus*. Pectoral fin supported on basal segments, of which the anterior articulate with the scapulocoracoid element, and the posterior to the metapterygium, the whole forming a uniserial fin. Metapterygium unsegmented and fused with the basal elements which it supports.

The specimen on which this genus is founded throws much light on the structure of the Cladodont pectoral fin, and through it, on the question of the evolution of this organ among fishes. The fin basis described is mostly well preserved, and is clear as to details of structure. It confirms the characters ascribed by Traquair to the pectoral fin of *Cladodus* from the lower carboniferous of Scotland,[1] the only important difference being that in the latter the metapterygium is distinctly segmented, while in *Symmorium* this element forms a single piece, except possibly at the extremity. According to Traquair there is an "oblong" proximal segment of the metapterygium, "whose anterior portion seems to have absorbed the basis of one or two adjacent radials." In *Symmorium reniforme*, all the basals (radials of Traquair), are fused at their basis with the metapterygium. The basals are also more numerous than in Dr. Traquair's shark, for he says "some small radials are seen attached to the preaxial side of the first two segments—none on the others." My specimen agrees with Traquair's in the absence of basals (radials) from the postaxial side of the metapterygium, where indeed they are not to be looked for.

As this species is the only Cladodont from the coal measures in which the fin-structure is known, it is premature to suppose that all the species of that horizon, of which there are described, according to Newberry, 38 species of the genus *Cladodus* alone, belong to the genus *Symmorium*. But it is not unlikely that such will prove to be the case. The name *Cladodus* is applicable to the species of the lower carboniferous, to which it was originally given by Agassiz, where the metapterygium is segmented.

On a knowledge of the fin structure of the paleozoic sharks depends the solution of the question whether the tri- and pluribasal fins of the modern Elasmobranchs and Teleostomi have been derived from a pinnate archipterygium as supposed by Gegenbaur, or from a lateral fold supported by rays, as supposed by

[1] Geological Magazine, Feb., 1888, p. 82.

Thacher and Balfour. Traquair, after a study of his specimen, declares that it "is a witness against the lateral fold theory of the paired fins, at present so popular with anatomists and embryologists;" (l. c. p. 83). Dr. Smith Woodward[1] adopts both of the opposing views, deriving the modern fin, like Gegenbaur, from an archipterygium, and deriving the archipterygium from the lateral fold fin, which I have elsewhere called a *ptychopterygium*. This opinion is based on a study of the Cladodonts from the Cleveland Shale at the base of the lower carboniferous in Ohio, named by Newberry *Cladodus fyleri* and *C. herzerii*. According to Dr. Woodward and Mr. Dean,[2] who confirms the observation, the pectoral fin in these species is supported by basal ossifications, which issue in nearly parallel relation from the body wall. Dr. Woodward does not refer to the existence of any skeletal element as a basal support to these basal rays; but Dr. Otto Jaekel[3] asserts that there are basal plates comparable to the metapterygium of the modern sharks, and hence infers the modern character of the fin. He expresses this opinion after an examination of some of the specimens studied by Dr. Woodward and Mr. Dean. Dr. Woodward says "the segmentation of the rays" (of the pectoral fin of "*Cladodus*" *fyleri*), the persistence of one of the middle rays, with the concomitant partial fusion of the still further crowded and reduced bordering rays, would soon, in the writer's opinion, result in the archipterygium of Gegenbaur. It is moreover significant that the anterior (preaxial) rays are much more robust than the posterior (postaxial) rays, exactly as in all known examples of the "archipterygium." Dr. Woodward also admits the possibility of the single basis (mesopterygium) of the archipterygium, having resulted from a fusion of several basal elements, as supposed by Dr. Anton Fritsch, as in the dorsal fin of Rhipidopterygium falcis.

The lesson taught by the specimen of *Symmorium reniforme* is as follows: The metapterygium is not formed by the enlargement and segmentation of a median ray, or basilar, but already exists as a plate or series of plates probably enclosed in the body wall or in its primitive fold. This metapterygial fold became subsequently free posteriorly from the body wall. The archipterygium is then formed from the ptychopterygium by the addition of basilars to its posterointernal face; while the tri- and pluribasal fins of modern Elasmobranchs and Teleostomi are the result of enlargement, reduction and fusion of the proximal radials. Thus the fin-structure discovered by Traquair, contrary to his supposition, supports the ptychopterygium theory, and the modern fin is not derived from the archipterygium, but from the ptychopterygium. From this we conclude that the Ichthyotomi (Fig. 1), are derivatives of the Selachii and not the reverse; a result which accords with the paleontologic succession. The converse supposition which I have hitherto entertained, does not coincide with this order, as no Ichthyotomi are

[1] Natural Science, March, 1892, p. 31.
[2] Transactions N. York Academy Sciences, April, 1893, p. 124.
[3] Sitzungsber. Gesel. Naturf. Freunde, Berlin, 1892, No. 6, p. 92.

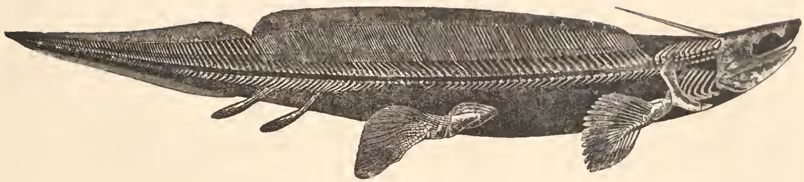


Fig. 1. *Xenacanthus dechenii* Goldf. From Fritsch, Fauna der Gaskohle u. d. Kalkstein Boehmens. Much reduced.

known from beds older than the Coal Measures, while Selachii are known from the Devonian.

The structure of the paired fins here pointed out sustains the views already announced by Mr. Bashford Dean in the paper quoted, and this author is to be congratulated that the view which he has put forth is so fully sustained by the material now described. One hypothesis which he holds requires further confirmation, viz.: that the metapterygium is formed by the fusion of the basal elements. The extensive fusion seen in the later genus *Symmorium* as compared with the earlier genus *Cladodus* supports his position so far as it goes; but the origin of the primitive segments is not thus explained.

Mr. Dean refers *Cladodus fylerii* to a genus distinct from *Cladodus*, which he calls *Cladoselache*. The character of the fins does not seem to differ from that ascribed to *Cladodus* by Traquair, and the geological horizon is that of the latter genus.

Mr. Dean thus states his conclusions, (l. c.):—

"It would appear that this shark form presents the most manifest evidence as to the lateral fold origin of the paired fins. The fins, as stated by Smith Woodward are actual remnants of the derm fold. The unjointed rod-like radials proceed from the body wall directly to the fin margin; the fin surface, therefore, is as yet lacking the specialization of the dermal margin and dermal rays. It would now appear that the basal plates exist but in a most primitive condition; their fusion into a plate is seen to occur to a partial degree in the pectoral fin, but the rotation outward of the posterior end of this trunk of basals does not as yet take place; the entire fin stem is still imbedded in the body wall. In the ventral a most interesting condition occurs,—a more primitive arrangement would here very naturally be expected,—*the basals in the body wall are as yet unfused, and are represented by rod-like bars of cartilage*, which outwardly resemble basal joints belonging to the radials, and were, in fact, so interpreted by Jaekel. The proximal ends of the basals are in actual process of concentration near the anterior fin margin; the radials, however, are still more or less at right angles to the axis of the fish. Smith Woodward has already recorded one of the most significant features in the fin structure,—the marked way in which the radials are crowded together side by side in the *anterior* fin margin,—giving rise, in fact, in the pectoral to the specialization of a compact cutwater. The writer suggests that this tendency to compress the radial elements in the anterior fin margin could only occur when the line of the basals was still imbedded in the body wall,—and would trace this conclusion still farther to account for the anomalous fin spines of the Acanthodians. In *Parexus*, for example, it would seem quite clear that the broad fin spine is structurally compound, and may well represent the fusion of the radials in the anterior fin margin."

"In the ventral of *Cladoselache* is represented the most primitive condition hitherto known in the ontogeny of the paired limbs. The fin is still outwardly a body derm fold, thrice as long as broad, blunted anteriorly where the radials are beginning to be clustered; the basal supports, in number scarcely less than the appended radials, are still unfused, although the process of concentration anteriorly is clearly to be marked."

To this I have added,[1] that my observations on *Symmorium*, together with those of Traquair, Jaekel and Dean, show that the median axis of the archipterygium is not propterygial or mesopterygial, but is metapterygial. This greatly simplifies the conception of the history of the Selachian fin (Fig. 2), where the metapterygium supports the greater number of the other segments. The Ichthyotomi are thrown out of the phylogeny of the sharks, and are left in a position more likely to prove ancestral to the Teleostomatous fishes; but nothing positive on this point can be affirmed.[2]

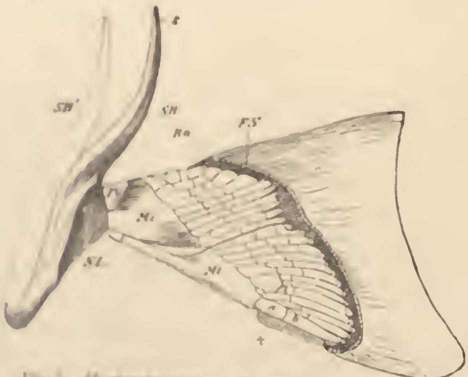


FIG. 1. [illegible], left pectoral fin, pluribasal type. S.F. scapular arch; N.L. foramen; Pr, propterygium; Ms, mesopterygium; Mt, metapterygium; a b, axis of metapterygium; Ra, basalia; F.S, fin-rays. From Wiedersheim.

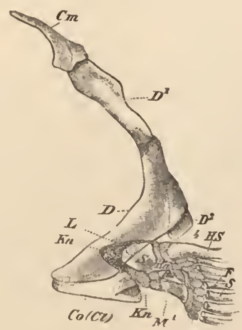


FIG. 3. *Salmo fario*, left shoulder-girdle; *Cm*, posttemporal; *D*¹, epiclavicle; *D*, clavicle; *D*², postclavicle; *S*, scapula; *Co* (*Cl*), coracoid; *M*¹ *Ra*, basitars; *L*, scapular foramen; *HS*, *FS*, fin-rays. From Wiedersheim.

[1] Proceedings Amer. Philos. Soc., 1892, 280.
[2] American Naturalist, Nov. 1900, p. [illegible]

It is further to be observed that the essential distinction now discovered between the metapterygial and other elements of the paired fins, must be maintained in our future studies of them. A clear distinction between baseosts and axonosts in the paired fins has been hitherto wanting. For the present it may be convenient to regard the metapterygial elements as axonosts, and those which have originally been branches of that axis, as baseosts. The scapular base of the Selachian fin (Fig. 2) consists then of one axonost and two baseosts. The Actinopterygian fin will have as its scapular base, according to Gegenbaur's homologies, baseosts only, the metapterygial (axonost) elements having entirely disappeared (Fig. 3).

Taxonomy.—As a result of the preceding observations, I have removed the Cladodontidae[1] from the Ichthyotomi, where Dr. Woodward placed them, and have relegated them to his order of Acanthodii. The definitions of the three orders derived from the fins, will then be as follows; those of the second and third being the same as given by me in the American Naturalist for 1889 (October, p. 854):

Paired fins ptychopterygial;	*Acanthodii.*
Paired fins archipterygial;	*Ichythotomi.*
Paired fins basilo-metapterygial;	*Selachii.*

Char. Specif.—This species is established on the anterior part of the skeleton of an individual from the shales of the Coal Measures near Galesburg, Knox Co., Illinois. The fragments include parts of the skull, hyoid arches and pectoral arch, in a damaged condition. The jaws, which are preserved, display a considerable number of teeth more or less displaced. One mandibular ramus is identifiable, but the other tooth-bearing elements are not certainly determinable.

The teeth display all their surfaces, so that their characters are readily ascertainable. They are all alike, differing only in size, those near the center of the specimen being smaller than those more distant, and representing probably a more posterior position on the jaws. The base of the tooth is reniform in outline, the anterior border concave, the posterior convex, and the extremities obtusely rounded, or subtruncate. The principal cusp is about as high as the base is long. It is flattened anteriorly, and very convex posteriorly, and is curved backward. The anterior surface is finely striate, and the posterior face is more strongly and sharply striate with close and fine ridges. The two faces are separated by a cutting edge. The apex is smooth, and presents a low angle on the anterior face. There are two basal cusps on each side, the external larger, but much smaller than the median. It is curved backward, has no cutting edges, and the surface is striate-grooved. The middle cusps are smaller, and acutely conic. All the cusps stand on the anterior border of the base.

The characters above enumerated show that this species differs from each of the numerous forms described by Newberry in the reports of the Geological Surveys of Ohio (Vol. II), and Illinois (Vol. II), or by St. John in the same (Vol. VI), or by Newberry in his work on Paleozoic Fishes in the Monograph No. XVI of the U. S. Geological Survey. It resembles most *C. lamnoides* Newb. and *C. intercostatus*,

[1] Amer. Naturalist, 1893, Nov., p. 999.

C. eccentricus and *C. fullerii* of St. John (l. c., Vol. VI). From the first-named it differs in its reniform instead of semicircular base, and in the possession of two denticles on each side instead of one. From *C. intercostatus* it differs in the absence of distinct ridges of the crown, and in the absence of tuberosities of the inferior surface of the base. In *C. fullerii* the base is of lenticular outline, and in *C. eccentricus* it is deeply excavated below, characters not seen in any of the teeth of *C. reniformis*. I should, however, have hesitated to add another name to the list of species of this genus but for the interest which attaches to some portions of the accompanying skeleton, to which I will now devote a short space.

The cranium is too much crushed to furnish useful information. There is no trace of spine, such as occurs in *Xenacanthus*. Posterior to it the numerous elements of the hyoid arches show that the epibranchials terminate in free acute apices above, as in recent sharks. There is a scapulocoracoid which has much the form of that of *Xenacanthus*, as described by Fritsch in his admirable monograph of this genus.[1] From the external angle of this element there extends the elongate axis of the pectoral fin. It is not completely segmented, the anterior portion being covered by continuous granular ossification. The posterior border is divided comb-like into numerous short divisions, with squarely truncate extremities, which appear to have supported the basal elements of the fin, although but few basal segments have been preserved, and but two of them appear to be in place. They are much more slender than the truncate articular faces, and the two referred to articulate with a single one of the latter.

MEASUREMENTS.

		MM.
Diameters of base of tooth No. 1	anteroposterior;	5
	transverse;	10
Diameters of base of tooth No. 2	anteroposterior;	6
	transverse;	12·5
Elevation of crown of No. 3;		9·5
Length of base of No. 3;		12·5
Length of longer branch of scapulocoracoid;		130
Length of axis of pectoral fin;		170
Width of articulation of basilar on axis;		6

I owe the opportunity of studying this specimen to Mr. F. R. Jelliffe, to whom my thanks are due.

Genus OROdus Agass.

Orodus [illegible] sp. nov. Plate XVIII, Figs. 6-7.

A slab of slate from the coal measures of Galesburg, Illinois, contains the anterior half of the length of a fish of the genus *Orodus*, as a granular carbonaceous mass. Of the elements of the skeleton only the mandibular and scapular arches of one side are distinctly outlined. In the mouth the dentition is preserved in a con-

[1] Fauna der Gaskohle und d. Kalksteine der Permformations Boehmens, Band III, Heft I. Prag., [illegible].

fused condition. The teeth can be seen from all points of view, and a good idea of their characters can be obtained.

The muzzle does not project beyond the lower jaw, so that the mouth is terminal. The teeth are confined to the anterior half of the mouth. They are narrow, and are arranged end to end in arched rows. The crown is keeled on the middle line, a part of the keel not exactly in the center, rising into a low angle. The edge is not serrate nor beaded, but is feebly crimped in some teeth, and apparently smooth in others. The surface is otherwise entirely smooth; but there are on one side three low vertical keels. The base of the crown projects over the root on both sides, but on one side much more than on the other, so that teeth lying on their side, look like short cylinders. The root is coarsely porous, the openings being frequently as large as the space between them.

This species resembles in dentition, in some measure, such forms as *O. minusculus* N. and W.[1] and *O. elegantulus* N. and W.[2] The former has, according to its describers a distinctly beaded median keel, and in the latter the crown is transversely ridged; in neither is its swollen base described nor figured. The presence of vertical crests on one side of the crown, places the *O. basalis* in the section Agassizodus St. J. and Worthen. In this genus it resembles *O. virginianus* St. J. and W.,[3] and *O. scitulus*[4] St. J. and W.; but it is more slender, and has fewer crests than the former, and is less slender and more symmetrical than the latter.

The mandibular ramus becomes shallower posteriorly than at the middle. The scapular arch has the position usual in sharks, and the horizontal anterior portion rises gradually into the much longer vertical portion, which has the anterior border straight. The pectoral fin is too much damaged for interpretation.

MEASUREMENTS.

	MM.
Length from end of muzzle to superior apex of scapular arch:	225
Length of mandible to cotylus;	116
Depth of mandible at middle;	22
Depth of inferior limb of scapular arch;	21
Length of a tooth;	6·5
Depth of same tooth at apex;	4·5
Depth of crown of same tooth;	3·5

One half of the slate containing the specimen above described, is contained in the State Museum at Springfield, Illinois. It was kindly lent me by Dr. Joshua Lindahl, State Geologist. Through him I learned that the other half was in possession of Mr. Frederick R. Jelliffe, of Galesburg, Ill. Mr. Jelliffe very kindly sent me his specimen, together with the one already described as *Symmorium reniforme*; and I here express my appreciation of his kindness in so doing.

[1] Report of the Geological Survey of Illinois, II, 67; Pl. IV, Fig. 11.
[2] Report of the Geological Survey of Ohio, II, 67; Pl. VI, Fig. 6.
[3] L. c. VI, Pl. VI, Fig. 16.
[4] L. c. VI, Pl. VIII, Fig. 23.

Associated with these specimens is a fish spine referable to the genus *Listracanthus* N. and W., and approaching the species *L. hystrix* N. and W. It is well preserved, displaying both base and apex. For the greater part of the length there are eight longitudinal keels on the surface, but at the base there are ten. Newberry, (Geol. Survey of Ohio Vol. II), in his figure, represents the *L. hystrix* as having thirteen ridges (counting the borders) to beyond the middle of the length, but as no number is given in the description, I cannot make a certain identification. It is represented on Plate XIX, Fig. 3.

Genus STYPTOBASIS Cope.

STYPTOBASIS A[illegible]ATA sp. nov. Plate XX, Figs. 1-5.

Established on the anterior part of a fish, including the head, scapular arch, etc., from the coal slates of Galesburg, Illinois. The details of the structure are not well preserved, but many teeth are visible.

The cartilage is covered by a close tessellation of minute ossifications. The teeth are remarkable for the absence of the expanded basal portion or root which characterizes the allied genera *Cladodus*, *Lambdodus*, etc. The base of the crown is slightly expanded, but the root proper is wanting or rudimental. The lateral denticles are normally wanting, although in the anterior part of the lower jaw a tooth is preserved with a denticle attached by a slender basal connection. I refer the species provisionally to the genus *Styptobasis* which I proposed[1] for a probable Cladodont without expanded root or denticle, although it is quite possible that when skeletons of the *S. aculeata* and *S. knightiana* are better known, they may be found to belong to different genera. It is possible that the genus termed *Mesodmodus* by Claypole[2] will turn out to be identical with *Styptobasis*, although the base of the tooth is in the former a little better developed.

Two elements behind the skull appear to be the scapular. They are subtriangular, with the apex superior; the anterior border projecting forward as it extends downward and the posterior border being nearly vertical. A trace of the base of the pectoral fin is present, but is in poor preservation.

Char. Specif.—The specimen does not furnish clear characters in some respects, as the head is crushed and distorted, and the dorsal region of the body is very imperfect. Nevertheless, the form of the lower jaw and the characters of the teeth may be distinguished. The latter are lying in confused relations along the palatopterygoid and mandibular borders, but at one place the bases of several are attached to the border of the jaw. They are of different sizes and forms, as follows: On the middle portions of the jaws the teeth have long and slender crowns which are compressed, and curved in the direction of the long diameter. On the posterior parts of the jaws the crowns are much shorter and more robust, but are compressed and curved like the others, the curvature being more strongly marked as the crowns are shorter. On the anterior parts of the jaws, the teeth are shorter than in the middle, but more slender than on the posterior region. A single tooth

[1] Proc. U. S. National Museum, 1891, 447.
[2] American Geologist, May, 1893, p. 329.

here presents the appearance of having a minute denticle on one side separated by an attenuated line of base. The surfaces of all these teeth are closely and sharply grooved from the base to near the apex, which is smooth. Where clear views can be had, the base of the crown is seen to be round; and although the crowns are compressed, there seems to be no cutting edge, and the apex is round and needle-like.

MEASUREMENTS.

	MM.
Length of an anterior crown;	2
Length of a median crown;	4
Diameter of a median crown at base;	·75
Length of a posterior crown;	1·50
Diameter of a posterior crown at base;	·75
Length from extremity of lower jaw to scapula;	1·45
Anteroposterior width of scapula at pectoral fin;	·20

This species was found by Mr. Frederick R. Jelliffe near Galesburg, Ill., in the shales of the Coal Measures, at the same locality as that which yielded the *Symmorium* and *Orodus* here described.

Genus DELTODUS N. & W.

DELTODUS PLANIDENS sp. nov. Plate XX, Fig. 6.

Two teeth of the inferior series represent this cochliodont shark. One tooth, which belongs to the left side, is completely preserved, and shows a transverse involution which amounts to nearly an arc of 360°, but of a depressed outline, and much more curved, at the apex than at the base as is usual. The surface of the crown is distinguished by the absence of ribs and grooves transverse to the direction of the ramus of the jaw, but the anteroposterior section is uniformly slightly convex. On the other hand it is marked by shallow grooves running parallel to the convex internal border, which become more pronounced and closer together as the apex is approached. These grooves fade out on the longer or posterior border of the crown, but terminate abruptly before reaching the anterior border, at the internal extremity of the crown. On the external and narrower part of the crown, the grooves extend to both borders. The pores are uniformly distributed over the surface. The length of the grinding surface round the curve is 57 mm.; length of long chord of tooth, 31 mm.; width of interior base of crown, 30 mm.

This species belongs to that small section of the genus in which the teeth possess longitudinal grooves. In this it resembles *D. undulatus* and *D. cingulatus* of Newberry and Worthen. But the teeth of the former species have ribs and a wide groove transverse to the jaw; while the latter much narrower teeth with the pores in bands corresponding to the longitudial (transvere) ridges.

The present species was found by Mr. W. F. Cummins on Tecumseh Creek, northern Texas.

PLEURACANTHIDÆ.

The Genera of Pleuracanthidæ.—In the catalogue of fossil fishes in the British Museum, Mr. A. Smith Woodward[1] admits but two genera of the *Pleuracanthidæ*, viz., *Pleuracanthus* Agass. and *Chondrenchelys* Traquair. In the Fauna of the Gaskohle, etc., Bœhmens, already cited, Dr. A. Fritsch adopts three genera, viz., *Pleuracanthus*, *Orthacanthus* and *Xenacanthus*. Dr. Woodward, in commenting on this circumstance, does not agree with Dr. Fritsch in separating these forms as genera, a position which appears to me to be well taken. Dr. Fritsch's specimens include some in which the crania are in a good state of preservation. These show that the frontal cartilages are not produced posteriorly into two cornua as is the case with the American species which I have described from the Permian formation of Texas under the generic name of *Didymodus*.[2] It is evident therefore that this genus is distinct from *Pleuracanthus* and should not be united with it, as has been done by Dr. Woodward in the catalogue of the fossil fishes above cited.

TELEOSTOMI.

RHIPIDOPTERYGIA.

MEGALICHTHYS Agass.

MEGALICHTHYS MACROPOMUS, Cope. Plate XIX, fig. 1.

Proceed. Amer. Philos. Society, 1872, p. 225.

Established on the greater part of an individual from the Carbonic system of Kansas. With the exception of a short interval just behind the head, the specimen is complete as to its length; the pectoral and ventral fins are damaged, and the extremity of the anal is broken off. The scales of one side of the body only are visible in the present state of the specimen, and a good many of those of the abdominal region are lost.

The general characters may be enumerated as follows: The form is slender. The scales are large and rhombic, with rounded extremities. The supratemporal (cheek) bones and opercula are very large, and are much extended posteriorly. The enamel is present on the superior aspect of the skull in small and irregular patches only, but it covers the rest of the external surfaces. It is everywhere closely and minutely impressed-punctate. The bones of the skull are thin and light.

The elements of the skull are distinguishable for the most part, the sutures being obliterated on the nasal region. The pterotics (squamosals Traquair) are longer than the postfrontals, and the parietals are longer than the frontals. The supratemporals (cheek-bones Traquair) are very large, extending posterior to the posterior border of the parietals. The tabularia[3] are large (supratemporals

[1] Catalogue Brit. Museum, Feb., 1888. Pt. I, p. 1, 1889.
[2] Proceed. Amer. Philos. Soc., 1884, p. 572.
[3] For the explanation of this term see Proceed. Amer. Philos. Soc. 1894, p. 110.

Traquair). The opercula are very large, and in this specimen they are shoved upward so as to overlap at the median line. Their length enters the total length of the skull three and a half times, and is a little greater than that of the parietal bones. Their superior margin is beveled off from a low longitudinal thickening from which some low wrinkles radiate downward. Enamel is present on the superior surface of the skull, on the border of the frontal bone posterior to the orbit, and on the anterior part of the postfrontal bone. There are grains of enamel scattered on the parietals. On the supratemporals there are closely placed, concentric, interrupted lines on the superior part, and irregular patches of larger size on the inferior part. There are large patches of enamel on the opercula. The superior bones of the skull are everywhere roughened with minute tuberosities, which fuse into transverse ridges on each side of the sagittal suture. The maxillary bones are displayed partly on the superior, partly on the inferior faces of the specimen. They are rather slender, and their distal extremities are broken off.

There is a short pyriform symphyseal, entirely closed by the mandibular rami, and a median gular bone which joins the gulars with a concave suture. The gulars are large, and measure three times as long as wide at the middle. They are cut off obliquely on the inner side, posteriorly, by the chevron-shaped arrangement of the pectoral scales. Several large external gulars. The posterior extremities of the mandibles are broken so that their proportions cannot be exactly ascertained, but the length preserved is six times the width opposite the anterior gular. The surface of their inferior portions is marked by coarse impressed punctures besides the usual minute ones. The former are not present on any other part of the fish

The scales are large; between the bases of the pectoral and ventral fins can be counted about twenty-one rows, and between the ventral and the first dorsal immediately above, eight rows. The first dorsal fin is above the ventral, and the second dorsal above the anal. There are two large scales on each side which embrace the base of the first ray of the first dorsal and anal; the other fins are too imperfect at the base for description. The caudal fin is shortly heterocercal, and there are six broad fulcral scales projecting from the side of its inferior border. In all the fins the rays are segmented. A half dozen rays near the border are coarse, but the remaining rays are finer. In all the fins the coarse rays are distally subdivided.

Measurements.

	MM.
Total length of specimen (20 mm. intercalated behind head)	950
Length to anterior border of orbits	45
Length to posterior border of parietals	143
Length to posterior border of operculum	230
Length to anterior base first dorsal fin	620
Width between orbits	33
Width of parietals and postfrontals anteriorly	38
Width of parietals and pterotics posteriorly	75

Length of symphyseal bone	15
Length of anterior gular	13
Length of gular	120
Length of first dorsal fin	110
Length of caudal from inferior base to superior free apex	135
Depth of body at first dorsal	85
Depth of body at second dorsal	50

This species is not nearly allied to the species from the Permian of Texas, *M. nitidus* Cope, which is smaller and more robust in form. It has its scales and ganoine, generally, perfectly smooth, and there are but fourteen rows of scales between the pectoral and ventral fins. From the European species with punctate ganoine it differs in the longer gular bones and more elongate head, so far at least as concerns *M. hibbertii* and *M. laticeps*. In *M. pygmæus* the scales are described as coarsely punctate by A. S. Woodward. Its dimensions are about equal to those of *M. hibbertii*. The crescentic ganoine scales of the muzzle of that species and *M. nitidus* are absent from *M. macropomus*.

I owe the opportunity of examining the beautiful specimen which is described above, to my friend Mr. R. D. Lacoe, of Pittston, Penna., whose valuable collection of paleozoic fossils is of such utility to students of the subject.

? CROSSOPTERYGIA.

SPERMATODUS Cope

SPERMATODUS PUSTULOSUS gen. et sp. nov. Fig. 4.

Char. Gen.—Based on the left half of a skull, which includes the median elements, parietal and frontal above, and basioccipital and parasphenoid below; with maxillary, palatine and mandibular bones, and one-half of the branchial apparatus. The posterior border and postero-lateral angle of the skull are broken off.

The basioccipital shows a cotylus for the first vertebra in front of the position of the foramen magnum, since the latero-superior parts of the bone are produced posteriorly beyond the cotylus. The axis of the bone is almost entirely ensheathed in the parasphenoid, which is emarginate posteriorly. It is elongate and rather narrow, and with openly concave lateral margins. Its anterior fourth is openly grooved at the center, and the oblique border which connects the lateral with the anterior obtuse border, is placed downwards. A patch of densely placed small pisiform parasphenoid teeth begins at the posterior third of the length, and extends as far as the beginning of the anterior sixth, being bifurcated so as to avoid the median groove. They are not well represented on the anterior part of the bone on the accompanying Fig. 4.

The supposed palatine bone supports small, obtusely conic, robust teeth. No teeth are observable on the maxillary or dentary bones, perhaps because the edge of the former is broken, and the latter concealed.

There is a well marked transverse groove at the position of the coronal suture.

Fig. 4. *Spermatodus pustulosus* Cope; A, B nat. size; *a*-*d* x 4. A from above; B from below; *a* supposed palatine teeth; *b* pustules on the frontal bones; *c* do on the maxillary; *d* parasphenoid teeth. *Mx*, maxillary; *Hm*, hyomandibular; *Pa*, parietal; *BO*, basioccipital; *Ps*, parasphenoid; *BH*, basihyal; *CH*, ceratohyal; *I*, *II*, *III*, ceratobranchials.

The branchial apparatus consists of basihyal and a series of lateral pieces which represent the ceratohyal, and three or four ceratobranchials, according as we regard the first lateral element as mandible or ceratohyal. I will provisionally assume that the branchial apparatus includes a ceratohyal and three ceratobranchials. The supposed ceratohyal is single, and is compressed. The ceratobranchials are rather slender. The basihyal is massive, has a single truncate surface, and resembles somewhat that of *Polypterus*, but is larger relatively to the other elements. The basibranchial is bifurcate posteriorly; whether deeply or shallowly depending on the interpretation we adopt of two fissures which cross each branch symmetrically a short distance posterior to the fork. If these are sutures, the elements distad to them are the (assumed) third ceratobranchials. These elements are flat as in the corresponding parts of *Polypterus*.

The sculpture of the superior surfaces consists of minute tubercles of enamel.

The resemblance of the corresponding parts of this skull to that of *Polypterus*, suggests that it is a member of the superorder *Crossopterygia*. This is seen in all the points above described. The base of the skull is widely different from that of *Megalichthys*, which I described in 1883,[1] and is one which is characteristic of modern fishes. It remains an unsolved problem whether all Rhipidopterygian fishes exhibit the structure seen in *Megalichthys*. The basal elements in *Spermatodos* differ from those of *Polypterus* in the absence of the lateral processes of the latter, which simulate reverted basipterygoids; and in the much less production of the basioccipital cotylus. The characters of the basihyal bone, the parasphenoid teeth, and the cranial sculpture have considerable resemblance in the two forms.

Char. Specif.—The general shape of the head is broad and flat. The occipital cotylus is circular in outline. The parasphenoid tooth-patch has an elliptic posterior outline, and the teeth are crowded, and measure from ·4 to ·3 millimeter in diameter. The parasphenoid is 5·5 times as long as wide at the middle. There are two rows of palatine teeth, but whether they are on different bones or on a single crushed bone, is not easy to determine. They are displayed on the superior surface of the specimen by the crushing of the parts. The teeth are rapiform, with acuminate apex, and striate enamel. They generally stand four in a space of five millimeters, with short interspaces. The largest are a millimeter in diameter. In the longest row, probably imperfect, there are eight teeth. The cranial sculpture is probably considerably worn off by exposure. It remains on parts of the frontal and maxillary bones. It resembles greatly a collection of minute pustules. The bony tissue is elevated into small tubercles, which are capped with enamel, which is sharply distinguished from the osteine. When the enamel is lost there remains a pit in the tubercle. The tubercles are oval on the frontal, and oat-shaped at one point on the maxillary.

The basihyal is turned with the anterior face posteriorly. This face is not divided into two for the hypohyals as in *Polypterus bichir*. It is a transverse oval with one long side flat, and the other concave. The ceratohyal is flat, and becomes

[1] Proceed. Amer. Philosoph. Soc., p. 628.

quite thin posteriorly. Its anterior extremity is excavated into an oval cup. The supposed mandible is flat, and in a horizontal plane, but is more robust than the ceratohyal. If there were any orbital bones they have left no traces.

MEASUREMENTS.

		MM.
Transverse diameter skull near posterior end of maxillary;		200
Length of parasphenoid;		86
Width of parasphenoid at occipital cotylus;		25
Width of parasphenoid at middle;		16
Diameters of anterior face of basihyal;	vertical;	11
	transverse;	27
Width of basibranchial;		9
Length of ? ceratohyal;		80

The specimen above described was found by Jacob Boll in the Permian formation of Texas.

ACTINOPTERYGIA.

LEPIDOTIDÆ.

MACREPISTIUS Cope.

MACREPISTIUS ARENATUS, gen. et. sp. nov. Plate XIX, Fig. 2.

Cha. Gen. Dorsal fin elongate, consisting of many rays; caudal fin demi-heterocercal, with fulcra on the superior border; anterior to this fin the fulcra are little different from ordinary scales. Scales rhombic. Teeth on premaxillary bones, vomer and palatines, all with obtusely rounded crowns on short peduncles, excepting those on the premaxillary and the opposing part of the dentaries, where they are a little more conic. Usual head bones present, including supraorbitals, suborbitals and preorbital.

This genus appears to be referable to the *Lepidotidæ*[1], as defined by Prof. Zittel,[2] although the evidence will not be conclusive until the anal and the paired fins are known. It differs from *Lepidotus* in the elongate dorsal fin, and in the absence of "meisselförmigen Zähnen" on the premaxillary. I propose that it be called *Macrepistius*. I add some other characters which may be of more than generic significance. The maxillary bone is well produced posteriorly, but the mandible is produced much farther. The ceratohyal is well developed, and the branchiostegal rays are osseous and robust. No gular nor intermandibular bones. Preopercular and other facial bones, unarmed. A considerable fossa anterior to the position of the ethmoid, which is bounded by an osseous bar on each side: but

[1] Palæontologie, Palæozoologie, III, p. 207.

[2] In the American Naturalist for 1889 (December) I proposed the names of Dapediidæ, Lepidotidæ, Macrosemiidæ and Aspidorhynchidæ, in place of the names Stylodontidæ, Sphærodontidæ, Saurodontidæ and Rhynchodontidæ of Zittel: names which are not taken from genera contained within them, and one of which (Saurodontidæ) is preoccupied.

whether these bars are premaxillary spines or not, can not be made out in the present state of the specimen.

Char. Spec. This species is represented by a specimen of which the greater part is preserved, including the head, much of the body, and the caudal region and fin. The head with parts of eight rows of scales has been pinched off from the rest of the fish by rock compression, and no exact contact between the fragment and the rest of the body can be found. The proportions of the body are thus not posteriorly ascertainable, but the discoverer found the two parts in juxtaposition and the scales on them are identical in character.

The form of the body was apparently fusiform. The radii of both the dorsal and caudal fins are rather finely branched at their distal portions. The scales are subequal and are rather sharply rhombic, and are arranged in the usual oblique bands. They extend much farther on the upper than on the lower base of the caudal fin. Their ganoid surface is marked by a few shallow and irregular fossæ, which are more closely spaced on the scales near the head than elsewhere. The scales are of medium size, and there are twenty-three in an oblique row, commencing at the supposed position of the first ray of the anal fin, and extending upward and forward to the dorsal fin. The portion of the dorsal fin which is represented in the specimen contains thirty-two rays, or spaces for them. They are moderately stout, and are soon divided.

The head is short, and the premaxillary border overhangs the dentary bones. The profile descends steeply, and almost vertically, in front of the orbits, and rises from the less sloping frontal region to the posterior parietal border. The front is nearly flat in the transverse direction. The superior plane of the skull is formed by the frontal and parietal bones, and pterotics and occipitals are not visible. An imperforate subtriangular supratemporal. Supraorbitals rather narrow; suborbitals large, few in number. Diameter of orbit entering length of head 5·75 times. Operculum twice as deep as long, and three times the size of the suboperculum. The latter is four times the size of the triangular interoperculum. The premaxillary bone is short; the maxillary is long, and moderately deep, presenting an acute angle upward at its posterior extremity, which is below the posterior border of the orbit. Posterior extremity of dentary bone below the middle of the posttemporal bone. It supports sixteen teeth, the distal more slender than the proximal, and the extremity of the bone is edentulous. The vertex to a convex border connecting the orbits in front, the opercular bones, except the preoperculum, and parts of the subopercular bones, are granular with ganoine. These grains are largest on the parietal bones, on whose posterior regions they are more or less confluent.

MEASUREMENTS.

	MM.
Total length of fragment of body:	272
Total length of fragment with head:	117

Depth of body at a point 115 mm. anterior to base of inferior caudal lobe;	75
Length of superior lobe of caudal fin from middle of base of fin;	85
Do. from last scales;	46
Long side of a scale;	7
Short side of a scale;	5
Length of head from muzzle;	90
Length of head to end of maxillary bone;	48
Length of head to free border of preoperculum;	74
Depth of operculum;	40
Interorbital width;	24
Parietal width;	39
Depth of skull from posterior border of parietal to interoperculum inclusive;	78
Depth do. at middle of orbit to dentary bone inclusive;	53

This species and genus are of considerable interest as representing for the first time in our knowledge, the Jurassic family of the Lepidotidæ on the North American continent. The generic type is a modification of the typical form, appropriately to the fact that the horizon from which it was obtained is generally supposed to lie at the base of the Cretaceous system, and Comanche series, of Hill. Dr. Hill, through whom I obtained the specimen, states that it was derived from a calcareous stratum which lies between the upper and lower sands of the Trinity series, at Glen Rose, Texas. Other vertebrate remains obtained by Dr. Hill at the same locality I determined to belong to a small crocodile. Dr. Hill informs me that numerous mollusca are found at the same horizon, which he has determined to be of Neocomian age. Dr. Lester F. Ward has determined plants from the same, to be of Tuscaloosa (Potomac) age, which is nearly Neocomian. I take the present opportunity of noting here that several years ago, Mr. Chas. H. Sternberg sent me from Kansas several teeth from the Dakota (upper Cretaceous) sandstone, which I suspect to belong to Lepidotid fishes.

PYCNODONTIDÆ.

The marine formations of the Jurassic and Lower Cretaceous systems are the horizons in which species of this family abound. As neither of these formations is widely distributed in North America, but few species of the family have been observed by American paleontologists. The only species thus far described have been derived from the upper Cretaceous formation. I now describe five species which were found in beds of lower Cretaceous age in Texas and Oklahoma.

MESODON Wagner.

MESODON DIASTEMATICUS sp. nov.

Founded on a vomer of an individual of large size, which supports a considerable number of the teeth in place. There are five series of teeth, of which those of

Fig. [illegible] *Mesodon* [illegible] Cope; vomer from below, natural size.

the median are larger than those of the lateral rows. There remain only four teeth of the median series, and one has been lost, the entire number being five. The outlines of their crowns are oblate circles, the anterior one absolutely circular. They are separated by interspaces equaling nearly or quite half their fore and aft diameters. The teeth of the first lateral row have much smaller, and subround crowns, which alternate with those of the median row, and are therefore separated by spaces equal to their own diameters. The anterior two median teeth are flanked each by a very small tooth of the first lateral row, and the same is true of the posterior tooth. The number of teeth in this row is thus eight. The teeth of the external row are both opposite and alternate to those of the median row; and they are therefore in contact and more numerous, numbering ten on each side. Their transverse diameter is generally a little greater than their anteroposterior. The lateral borders of the dental tract are parallel. None of the crowns are impressed.

MEASUREMENTS.

		MM.
Length of vomer below;		77
Width of vomer below;		38
Elevation;		46
Diameters of penultimate middle tooth	anteroposterior;	10
	transverse;	12·5
Diameters of antepenult of first lateral	anteroposterior;	7
	transverse;	7
Diameters of antepenult of external row	anteroposterior;	7
	transverse;	8

The specimen on which the above species is founded was obtained by Mr. J. B. Taff in some terrane of the Fredericksburg series of the lower Cretaceous system of Texas. It is of a brownish yellow color similar to the Pycnodonts described below from near Fort Supply, Oklahoma. It was submitted to me by Dr. E. T. Dumble, Director of the Geologic Survey of Texas.

Mesodon [illegible] Cope. *Microdus dumblei* Cope; Proceed. Amer. Philos. Soc. 1892, p. 128. Plate XX, Fig. 7.

This species is represented by a splenial bone of the left side, which supports four and a half rows of teeth. These do not form a close pavement, but are separated by interspaces. The external two rows include small teeth with crowns which are either round or slightly transversely oval. The teeth of the third row are larger and the crowns are all transversely oval. The teeth of the fourth row are of unequal sizes, commencing anteriorly of about the same size as those of the third row. The third tooth from the front, as preserved, is much larger, but is exceeded by the fourth; while the fifth is half as large again as the fourth. The sixth and last is a little smaller than the fifth. The teeth of the fifth row are as small as those of the first and second rows, and extend posteriorly to the anterior part of the fourth row, and not beyond. The crowns of the teeth are perfectly smooth and without keel or depression.

Measurements.

		MM.
Length of tooth series;		17
" " six teeth of external row;		10
" " six teeth of third row;		11·5
" " six teeth of fourth row;		16·5
Diameters of fifth of fourth row	anteroposterior;	3
	transverse;	7

The horizon of this species is not exactly known, but it is probably Lower Cretaceous or Neocomian. It gives me much pleasure to dedicate it to Dr. E. T. Dumble, Director of the Geological Survey of Texas, through whom I received the specimen.

URANOPLOSUS Sauvage.

Uranoplosus arctatus sp. nov. Plate XX, Fig. 8.

Represented by a vomer which supports five rows of teeth in good condition. I refer it to the genus *Uranoplosus* of Sauvage,[1] since it presents the characteristic peculiarity of the inferior surface. This presents three planes, a median and two laterals, which subtend an angle of the dental face on each side of the median row of teeth. These angles divide the grinding face of the most anterior tooth of that row preserved, but fall outside of the posterior teeth. But six teeth of the median series are preserved, and five of each of the laterals.

There are but five rows of teeth; the small intercalated teeth found between the larger lateral rows in the type of the genus, *U. cotteaui* Sauvg.,[2] being absent. The teeth of the median row are enlarged transversely, being about twice the diameter of those of the adjacent lateral series. Their anterior and posterior borders are nearly straight, and their grinding faces show, where unworn, a shallow transverse groove. The teeth of the first lateral series alternate or not with those of the median row, and are a little wider than long. Their anterior borders are a little concave, and the posterior convex, and continuous with the lateral convex border. The crowns are slightly concave when unworn. The teeth of the external row have the outlines of the crowns subround, and a little smaller than those of the first row; convex posteriorly, and a little concave anteriorly. All the crowns of the vomer touch each other, with a few slight exceptions.

[1] Bulletin Societé des Sc. hist. et nat. de l'Yonne 3d Ser. T. I, p. 47.
[2] Loc. cit., Pl. I, Fig. 1.

MEASUREMENTS.

		MM.
Length of median series of six teeth ;		40
Diameters of second tooth of middle series	anteroposterior ;	6
	transverse ;	14
" " " " " second series	anteroposterior ;	5
	transverse ;	8
" " " " " third series	anteroposterior ;	5
	transverse ;	6

This species differs from *U. colleani* in other characters besides the absence of the intercalated teeth. Thus the teeth generally are closer together in *U. arctatus*, and the transverse extent of those of the median row is greater.

The only specimen of this species known to me was found by Prof. A. P. Brown of the University of Pennsylvania, who accompanied me on an expedition undertaken in the interest of the Academy of Natural Sciences during the summer of 189[illegible]. It was found in a marine bed of Lower Cretaceous age about six miles N. W. of Fort Supply, Oklahoma. This bed Prof. Brown believes to represent the Comanche Peak terrane of the Fredericksburg division of the Lower Cretaceous.

URANOPLOSUS FLECTIDENS sp. nov. Plate XX, Fig. 9.

Established on a part of a palate from the same locality and formation as *U. arctatus*. This vomer has the same angulate character as the latter species and like it, supports five series of teeth. It differs from *U. arctatus* in the greater spacing of the teeth, which are rarely in contact with each other, and in the form of the teeth of the central row. These are strongly concave in front, and convex posteriorly, giving the form of a crescent, with the horns obtusely rounded. The size is also much less, the transverse width of the three median series of teeth, equaling that of the central series of *C. arctatus*. But size alone is not a good criterion of specific difference in fishes. The crowns are more worn however, than those of the large species, but this is in part due to attrition in moving water. The teeth of the external row are only represented by fragments. The crowns of the middle row show where least worn, a regularly convex smooth surface.

MEASUREMENTS.

		MM.
Length of four crowns of first lateral row ;		16
Diameters of tooth of median row	anteroposterior ;	4
	transverse ;	7
Diameters of tooth of first lateral row	anteroposterior ;	3·5
	transvarse ;	4

Found by Prof. A. P. Brown at the same locality of the *U. arctatus*.

COELODUS Heckel.

COELODUS BROWNII sp. nov. Plate XX, Fig. 10.

Represented by a part of the left mandibular ramus which supports the bases of five teeth in anteroposterior line. Two rows are distinctly represented, and a third internal row is represented by the extremities of the bases of the teeth only.

The distinctive character of the species is seen in great transverse extent of the teeth of the middle row, and the depressed ledge of the jaw just external to the smaller external row. The teeth of the middle row are narrow anteroposteriorly, the long diameter being about two and a half times the anteroposterior. They are inclined slightly backward externally. The crowns of the teeth of the external row are not over half the transverse diameter of those of the second, while of similar anteroposterior diameter. They are directed more obliquely backward than those of the second row, and they stand on a convex ridge of the bone, so that their grinding faces project beyond those of the second row. All the teeth are in contact. The only crown preserved is weathered; it does not display a median depression.

A single separate crown found near the present specimen, may belong to the same species. It is elongate, transversely gently arched, and its surface is without depression or sculpture.

Measurements.

		MM.
Anteroposterior extent of five teeth of external row;		24
Diameters of tooth of second row	anteroposterior;	5
	transverse;	14
Diameters of tooth of third row	anteroposterior;	5
	transverse;	7

From the same locality and horizon as the two species above described. The specimen on which *C. brownii* is founded was discovered by Prof. A. P. Brown, to whom I dedicate it with much pleasure.

EXPLANATION OF PLATES.

Plate XVIII.

Fig. 1–5. *Symmorium reniforme* Cope, part of specimen described on pages 428–32, one-fourth natural size. Lettering: Sc, Scapulocoracoid; P, Metapterygium; Eb, epibranchials; *s*, skull; *j*, jaw.

Figs. 2–3. *Symmorium reniforme* Cope, mandibular teeth, natural size; 2–3 from front; 2a, from below; 2b, from above; 2c, lateral denticles, enlarged.

Figs. 4–5. Branchial teeth, much enlarged.

Fig. 6. *Orodus basalis* Cope, head and part of body, two-thirds natural size.

Fig. 7. *Orodus basalis* Cope, tooth, internal side; *a*, external side; b. section.

Specimens in collection of F. R. Jelliffe.

Plate XIX.

Fig. 1. *Megalichthys macropomus* Cope, side of body and inferior surface of head, one-fourth natural size; *a*, head from above, three-eighths natural size. From collection R. D. Lacoe.

Fig. 2. *Macrepistius arenatus* Cope, side of head and body one-half natural size; collection E. D. Cope. Fig. 2*a*, head from above; 2*b*, mouth left side, some teeth supplied from right side, natural size.

Fig. 3. *Lystracanthus hystrix?* N. and W., nat. size; from collec. F. R. Jelliffe.

Plate XX.

Figs. 1–5. *Styptobasis aculeatus* Cope; coll. F. R. Jelliffe. Fig. 1, nat. size; Figs. 2–5, much enlarged; Fig. 2, osseous elements from mandible; Fig. 3, anterior teeth; 4, median, and 5, posterior tooth.

Fig. 6. *Deltodus planidens* Cope; nat. size. Coll. Geol. Survey of Texas.

Figs. 7–10. *Pycnodontidæ*, teeth, nat. size. Fig. 7, *Mesodon dumblei* Cope, coll. Geol. Survey Texas. 8, *Cranoplosus arctatus* Cope; Mus. Academy. Philada. 9, *C. plicatidens* Cope, do. 10, *Coelodus brownii* Cope, do. 8a, 9a, 10a, end views; 8–9, upper series; 7–10, lower series.

ON CYPHORNIS, AN EXTINCT GENUS OF BIRDS.

By E. D. Cope.

The genus *Cyphornis* is established on a species of bird which is represented by the superior part of a tarsometatarse. This fragment was obtained by Dr. George M. Dawson from a bed of indurated greenish clay of unknown age from Vancouver Island, and is the property of the Geologic Survey of Canada. The tarsometatarse is perhaps the most characteristic part of the skeleton of a bird, but under ordinary circumstances the determination of the present specimen might await better material, owing to its imperfect condition. The early acquisition of new material is, however, very uncertain, and as the characters are conspicuously peculiar, the best course seems to be to give it a place in the record.

The fragment has about the diameters of the corresponding bone in the American ostrich. The shaft is hollow, and is free from cancelli, and its walls are very thin. The three elements are distinguished by the presence of two septa, whose position shows that the lateral elements are of unequal diameters and very much more slender than the median. The tibial articular surface is imperfect, the lateral and part of the posterior border having been broken away, but the greater part of the internal face remains, together with the proximal end of the hypotarsus. The intercondylar tuberosity is large, and the surface posterior to it descends steeply to the proximal base of the hypotarsus. The external cotylus descends steeply to the anterior face, and is convex anteroposteriorly, but concave in an open groove transversely to the shaft. Posteriorly it descends steeply to the hypotarsus, forming a transverse obtuse ridge, which is concave transversely. The proximal end of the hypotarsus is depressed below the level of the tibial faces. The anterior face of the shaft is concave, forming a wide open groove, bounded on each side by an obtuse angle, that on the internal side becoming acute above. It is perforated proximally by an enormous pneumatic foramen, which shows only a trace of vertical division at its distal part, deep within its cavity. The external wall of this cavity rises directly to the angular border of the shaft, while the internal border is separated from the internal border of the shaft by a ledge-like continuation of the anterior face. The insertion of the *flexor metatarsi* tendons is of moderate size, and is divided into two unequal parts by a shallow groove. The posterior aspect shows the basal parts of two hypotarsal crests, which have been broken away. Of these the external is short and wide, and the internal is longer and narrower. From the latter the internal side of the bone descends steeply, and with a gentle concavity, and then convexity, to the anterior lateral angular border. Nearer to the internal hypotarsal crest than to the interior border, issues the rather large and subround internal posterior interosseous foramen. Between the hypotarsal ridges is a groove in the position of the principal channel for the tendon of the flexor digitorum muscle. However, it has a fossa just below its proximal end, which has some foramina in its walls, so that the function of the groove as a tendinous channel may be questioned. External to the groove is the broad base of the external hypotarsal crest. Its substance is coarsely cellular, and it is not traversed by any grooves. Its inferior extremity is but little below the transverse line of the internal posterior interosseous foramen. External to it is a second groove, which is narrower than the groove previously described, and it is bounded externally by a well-defined, but low ridge, which is convex posteriorly at the inferior part of the groove. From this ridge the external surface is gently convex to the antero-external. Between this groove and the inferior part of the external hypotarsal mass, is an oval foramen, its long axis parallel to that of the bone, probably the external interosseous foramen. The surface of the bone is everywhere smooth.

Measurements.

		MM.
Actual transverse proximal diameter;		38
Restored diameters of tibial faces	anteroposterior;	22
	transverse;	44
Diameters of shaft where broken	anteroposterior, at middle;	21
	transverse;	24
Diameters of anterior pneumatic foramen	vertical;	17
	transverse;	5
Width of base of external hypotarsal crest;		6
Width of base of internal hypotarsal crest;		3
From apex of intercondylar tuberosity to internal posterior foramen (axial);		20

In considering the affinities of this bird, we are somewhat embarrassed by the incompleteness of the hypotarsal crests. Their very coarsely cellular character leads me to think that they had no great elevation in their complete condition, and that the principal groove was not enclosed. Assuming this to have been the case, and regarding all the characters, there is no necessity for comparing this bone with the corresponding one of the Passeres, Pici, Coccyges, Psittaci, Heterospondyli,[1] Accipitres, Cecomorphæ, Chenomorphæ, Herodii and Grallae. Resemblances, actual or superficial, may be traced to the Ratitae, Gallinæ, and Steganopodes. Among the first named, this genus can only be compared to the genera with two hypotarsal crests, which are the Rheidæ, Apterygidæ and Dinornithidæ. From that of the Dinornithidæ the tarsometatarse differs in the extreme tenuity of its walls, and the large enclosed pneumatic cavity without cancellous tissue. From the known members of the other families it differs in the two posterior pneumatic foramina, and single anterior) and especially from *Apteryx* in the reduced size of the correspond-

[1] Cope, Syllabus Vertebrata, July, 1891, p. 58 (Stealornithidæ).

ing posterior foramen. In none of these genera is the exterior tibial surface deflected anteriorly, and in none of them is it elevated into a transverse ridge posteriorly. The corresponding region in *Gastornis* is imperfectly known. So far as described by Lemoine,[1] it agrees in these points with the other Ratitae, as does also *Diatryma*. which has also but a single hypotarsal crest.

Comparison with the Steganopodes shows much greater resemblances. The anterior aspect of the bone is almost exactly like that of *Pelecanus*. The posterior aspect resembles that of none of the order, in the absence of most of the tendinous grooves. This part of the bone resembles nearly that of some genera of Gallinæ, especially *Meleagris*, where, however, the tendinous groove is enclosed. This genus differs from it in every other respect, including the non-pneumatic shaft. Comparison with birds of the cretaceous period reveals a single point of resemblance to *Hesperornis*. This is the ridge-like elevation of the anterior part of the external tibial facet, which is in both genera connected with the intercondylar tuberosity. In no other respect is there any resemblance. No resemblance between this bone and that of the Dodo can be detected.

If we compare this bird with the Steganopodes we have as points of agreement the anteriorly deflected external tibial facet, the grooved posterior face, the narrow internal and wide external hypotarsal processes, and the high degree of pneumaticity. As additional points of resemblance to *Pelecanus* we have the huge anterior pneumatic foramen, and the narrow open groove of the external face. The posterior foramina have a similar situation. But the presence of a single tendinous groove indicates a wide difference of character, and the transverse ridge of the external tibial facet is scarcely indicated in any genus of Steganopodes.

In view of the above facts we may suspect real affinities with the Steganopodes, combined with affinities to more primitive birds with a simple hypotarsal structure. The Steganopodous foot, with its long second digit turned forward as in other vertebrates, is itself the most primitive foot among the Eurhipiduræ. On the characters adduced I propose the genus *Cyphornis*, and name the species *C. magnus*, which may be regarded as defined by the measurements and other specific characters above enumerated. It is said[2] that the birds described by Owen under the names of *Argillornis* and *Lithornis*[3] from the Eocene London Clay are allied to the Steganopodes. In none of the three species of these genera is the tarsometatarse preserved. They are all much smaller than the present bird.

The characters of *Cyphornis* indicate that the bed from which it was obtained, is not older than Eocene nor later than Oligocene.

As regards its habits it may be said that the pneumatic character of its foot bone renders it improbable that it depended on this member for habitual locomotion on land. In all the birds of terrestrial habit which I have examined, and of which I can gain

[1] Recherches sur les Oiseaux fossiles des Terraines Tertiaires inferieurs des Environs de Reims, Pl. I, p. 53.

[2] By Lydekker in Newton's Dictionary of Birds, I. p. 283.

[3] Annals and Magazine of Nat. History, XIV, p. 263. Trans. Geol. Soc. London, 2d Ser., Vol. VI, p. 206.

information, the tarsometatarse is either filled with cancellous tissue, dense or open, or the walls of the shaft are thick, as in the Emeu. The presumed affinity with the Steganopodes indicates natatory habits, and probable capacity for flight. Should this power have been developed in *Cyphornis magnus*, it will have been much the largest bird of flight thus far known.

EXTINCT BOVIDÆ, CANIDÆ AND FELIDÆ FROM THE PLEISTOCENE OF THE PLAINS.

By E. D. Cope.

During an expedition undertaken in the summer of 1893, in the interest of the Academy of Natural Sciences, I obtained some mammalian remains from southern Kansas, and western central Oklahoma, which add to our knowledge of the latest extinct fauna of those regions. At Wellington, near the middle of the southern part of Kansas, I obtained an almost entire mandible of an adult *Elephas primigenius* with the third molars only present, and half worn, said to have come from a sand bed on the western border of the town. Accompanying it were fragments of the skull of a large ox related to the bison, which is described in detail in this paper. From a similar sand bed on the eastern edge of the town, I obtained fragments of bones and a tusk with a molar tooth of the mammoth. From a locality about fifty miles west of the town of Hennesey, Oklahoma, I obtained teeth and bones of the mammoth; and associated with these were the teeth and part of the skeleton of a saber-toothed cat as large as a lion. The man who found these fossils informed me that the bones of the cat were mingled with those of the mammoth, and were generally on them, as though death had overtaken it while feeding on the carcass of the mammoth. This feline is the subject of a description in the following pages. The Oklahoma fossils are stained with the red ? Permian clay of that region, more or less of which adheres to them. This formation would furnish the material for any later deposit of a local character, or would become sufficiently soft in wet periods or places to engulf or overwhelm animals of the land.

CANIS Linn.

Canis indianensis Leidy, Jour. Acad. Nat. Sci. Phila., 1869, 368. *Canis primaevus* Leidy. Proceed. Acad. Nat. Sci. Phila., 1854, 200; Jour. Acad. Nat. Sci. Phila. 1856 III, 167. Pl. XVII, Fig. 11-12. Plate XXI, Figs, 14-16.

Portions of the superior dentition of a large dog were found by Prof. W. F. Cummins, in the Equus horizon of the Tule Canyon, on the Staked Plains[1] of Texas, and submitted to me for determination. Considerable interest attaches to the specimens, for the larger Carnivora which were associated with the horses, camels, etc., of the Equus Fauna, have been hitherto unknown.

The teeth indicate a dog of considerably larger dimensions than the wolf, and one differing from it also in the relatively greater anteroposterior diameter of the first superior true molar. The dimensions a little exceed those of the typical specimen of *Canis indianensis* of Leidy, which was described from a right maxillary

[1] See Annual Report of the Geological Survey of Texas for 1892; Report on the Vertebrate Paleontology of the Llano Estacado by E. D. Cope.

bone with teeth from Indiana. On comparison with Leidy's type which is in the museum of the Academy of Natural Sciences of Philadelphia, I find the following differences:

The second premolar is distinctly longer, and the external cingulum is much weaker. In *C. indianensis* this cingulum surrounds the crown posteriorly, and here in the present species the trace of it is especially weak. The internal root of the sectorial (first premolar) is inserted opposite to a point which marks the posterior third of the tooth in front of it, while in *C. indianensis* this alveolus is opposite that of its paracone. In the first true molar the protocone is more conic than in the Texas dog, having a round section, while in the latter it is lenticular. The external cingulum in the Texas dog is weaker.

The specimen from the Staked Plain belongs to an older dog than Dr. Leidy's type, which partly accounts for the weakness of the external cingula. I am inclined at present to regard it as an individual of the same species, suspecting that new material will confirm the reference. Leidy has referred a lower jaw from California to *C. indianensis.* This species and *Dinobastis serus* represent the largest Canidæ and Felidæ of the Equus bed respectively.

DINOBASTIS Cope.

American Naturalist, 1893, p. 896.

Generic character.—So far as preserved, the parts agree with those of the genus *Smilodon*, with one exception. This is that the superior sectorial tooth possesses no internal root, not even a rudiment. The protocone is wanting in *Smilodon*, but its corresponding root is present, but in this form the root also has disappeared, so that it may be regarded as presenting its last stage of specialization in the cats, a circumstance which is appropriate to its late appearance in time.

DINOBASTIS SERUS Cope, loc. cit. Plate XXI, Figs. 1-13.

The known remains of this species include parts of three metacarpals, three phalanges of probably a single digit, and the head of the femur. The teeth include five incisors, two superior canines, and two molars, one of them, the superior sectorial, in perfect preservation. The animal had attained full size, but the epiphysis of the head of the femur is not coössified. The dimensions are equal to those of a lion (*Uncia leo*), of the same age; and those of the superior sectorial are similar to those of *Smilodon fatalis* Leidy, and a little smaller than those of *S. neogæus* Lund, of South America.

Specific characters.—The canine teeth are large, with elongate compressed crowns, a little more convex on the external than the internal face. The cutting edges are finely serrate. The anterior edge differs from that of *Smilodon neogæus* in that it turns inward toward the base of the crown, presenting inward. In *S. neogæus* this edge is not incurved. The superior sectorial has a large anterior basal lobe and a rudiment of a second at its anterior base. The latter does not attain the importance of a lobe, as it does in *S. fatalis.* The part of the crown anterior to the paracone forms about one-fourth of the longitudinal extent of the crown; in *S. fatalis*, it forms about one-third. The paracone is prominent, and is strongly convex on the external face. The metacone has a nearly straight edge, and its external face displays a shallow vertical groove near the middle. The long diameter of its base is 1·5 as great as that of the paracone. The crowns of the external incisors are oblique, and slightly incurved; they have robust cutting edges, which are finely serrate, and no basal lobes. The incisors 1 and 2 have small conic lobes at the base of the crown, which are well separated from each other at their bases. Those of I. 1 are subequal, while the external of I. 2 is smaller than the internal, and nearer the base of the crown. The crowns proper of 1 and 2 are acutely conic with semicircular section, the posterior face being flat. The edges of I. 2 are feebly crenate; those of I. 1 are smooth.

The metacarpals represented are II, IV and V; of these No. IV is best preserved. It differs from that of the lion in the smaller transverse diameter of the head, and in the fact that the superior face of the diaclast[1] is nearly continuous with the proximal or unciform surface. The shaft is quite as robust as that of the lion. The shaft of the fifth metacarpal is on the contrary more slender. Its section is a triangle with convex limbs, and the obtuse apex external. The phalanges have forms and proportions similar to those of the fifth digit of the lion. The second phalange is a little shorter, and the margins display but small traces of the bases of the sheath, which has been broken off. Otherwise the ungual phalange resembles that of the lion.

MEASUREMENTS.

			MM.
Diameters crown I. 3	longitudinal;		22
	transverse;		13
Diameters crown superior canine	longitudinal;		80
	anteroposterior;		28
	transverse at base;		12
Diameters superior carnassial	anteroposterior;		35
	vertical	paracone;	18
		metacone;	13
Transverse diameter of head of femur;			40
Diameters head M.C.IV	anteroposterior (restored);		22
	transverse;		15
Transverse diameter shaft M. C. IV, at middle;			16
Anteroposterior diameter shaft M. C. IV, at middle;			11
Length of phalange ? V, 1;			38
" " " ? V, 2;			24
" " " ? V, 3;			22

[1] For explanation of this term see the Annual Report of the Geological Survey of Texas, 1892, Report of Vertebrate Paleontology of the Llano Estacado, p. 55.

This species, which I propose to call *Dinobastis serus*, increases the number of our Plistocene Felidæ to four. The three other species are *Smilodon fatalis* Leidy, *S. gracilis* Cope, and *Felis atrox* Leidy.

BOS Linn.

Bos crampianus Cope, sp. nov. Plate XXII, Figs. 1-4.

Founded on that part of the skull which is anterior to the orbits, the greater part of the left horn-core; and a smaller part of the right horn-core.

The muzzle displays characters similar in general to those of *Bos americanus*, including the concave palate and the incurvature of the alveolar border anterior to the premolar teeth. The nareal borders are also similar to those of that species, and the nasal bones are not generally different in form. Their extremities are lost in the specimen, as are those of the premaxillary bones. The expanse to the anterior orbital border is such as to render it evident that the width of the cranium at the orbit is greater relatively and absolutely than in *B. americanus*, the orbital border itself being broken away. The species is especialy distinguished by the great size and peculiar form of the horn-cores. The entire left core is preserved, except that some pieces have been lost from the inferior side, and the basal border is wanting. As it is, the fragment measures twenty-nine inches on the chord of its curve, or nearly three times the length of the longest core of the American bison which I have seen. The latter, which is part of the skull of an old bull in the museum of the Academy, measures eleven inches in the chord.

The horn-core is strongly curved, the apex pointing upwards and forwards. Its diameter diminishes regularly to the subacute tip. The surface is coarsely grooved longitudinally, the widest groove being on the posterior face. The posterior face is flat from near the base to the apex, the flattening being most conspicuous on the distal two-thirds of the length. It results that the section of the core is a triangle with a broadly rounded apex. A flattening of the superior face of the last ten inches of the length is at right angles to the posterior face, and forms with it a prominent angular ridge. The section at this point has a convex and two flat sides.

The great size of the horns renders comparison necessary with *Bos latifrons* only. The museum of the Academy contains the fragment of the skull from the Big-bone Lick, Kentucky, described by Leidy, which supports the basal third of the left horn-core. This specimen offers no trace of the flattening characteristic of *B. crampianus*. The only perfect cores of *B. latifrons* known to me are contained in the museum of the Society of Natural History of Cincinnati. They were found in a gravel bed in southern Ohio, and are figured by Dr. J. A. Allen[1] in his monograph on the American bison. These horns (from both sides) are represented as having a sub-circular section, and are without flat planes at any part of their length. The curvature is less, but this character may have a considerable range of variation.

[1] Memoirs of the Museum of Comparative Zoology, Cambridge, Mass.

This species is dedicated to Mr. Charles Cramp, of Philadelphia, who is as well known to the scientific community for his benefactions to our institutions of research and education, as he is to the general public as the most extensive builder of ships in the United States.

The dimensions of this species are as follows :

MEASUREMENTS.

		MM.
Vertical diameter of cranium at posterior end of diastema;		180
Width of palate at diastema;		140
Width of nasal bones at posterior border of nares;		100
Probable width at preorbital border;		360
Length of horn-core on outside curve;		720
Anteroposterior diameters	at base;	150
	at middle;	95
Vertical diameters	at base;	130
	at middle;	90

Professor Leidy regarded *Bos crassicornis* (Richardson) from Alaska, as identical with his previously named *B. antiquus*, a conclusion confirmed by Dr. J. A. Allen. Leidy subsequently regarded this *B. antiquus* as identical with *B. latifrons* of Harlan. With this identification Dr. Allen does not agree, but he holds that *B. antiquus* is a large race of *B. americanus.* The material in the possession of the Academy entirely confirms Dr. Allen's views. None of these forms possess characters of the *B. crampianus.* Those who regard the group Bison as a distinct genus, will call this species *Bison crampianus.*

BOS SCAPHOCERAS sp. nov. *Bos* sp. Leidy, Proc. Acad. Nat. Sci., Phila., 1886, p. 275.

A horn-core of the left side represents this species. A smaller core which accompanies it, and which was found with it, presents the characters in a less conspicuous degree, and may probably have belonged to a cow. These specimens are from a formation in the northern part of Nicaragua to which reference has been made by Leidy in the publication above cited. In it, he states, were found remains of *Equus, Bos, Elephas, Mastodon, Toxodon, Hydrochoerus* and *Megatherium.* As Leidy observes, this locality is far north of the most northern locality for *Toxodon* previously known. I would add that it is the most southern station on the American continent for *Elephas* and *Bos,* neither genus having been previously found south of the valley of Mexico. This local fauna is interesting as furnishing a geographical and faunistic connection between the Pampean of South America and the Equus bed of North America, since *Elephas* and *Bos* are here found with *Toxodon* and *Megatherium.* The single tooth of *Elephas* is not distinguishable from that of *E. primigenius americanus*; that is, it represents the thin plated form which lived in the eastern part of North America, rather than the heavy-plated type which prevailed in Texas or Mexico. The *Bos* I believe to be a bison, but of a different species from that which is indigenous to North America, and I accordingly describe it under the above name.

The horn-core of the supposed bull is very robust, more so than in *Bos americanus.* While the length equals and possibly exceeds a little that of the existing species, the diameters, especially at the base, much exceed the corresponding ones in that species. The horn is also more strongly recurved. These characters would not indicate more than race diversity, but the shape of the core is in other respects entirely peculiar. The transverse section is a triangle, the apex representing an inferior median angle, while the base is the section of the concave superior face. The plane of the deep anterior face of the horn produced, meets the plane of the superior face at an acute angle; while the plane of the posterior face meets that of the superior face at a right angle. Both anterior and posterior superior angles are rounded, the posterior the most so. The superior surface is flat throughout most of its length; rounding off conspicuously only at the base. The surface is not much grooved, but there is a shallow open sulcus on each side of the inferior obtuse median keel. There are several sharply defined parallel grooves near the apex on the superior face; the median commencing near the middle of the length, the others more distally; all issue from foramina. The small arterial foramina and grooves of the posterior side, are in lines at right angles to the axis of the skull, and therefore form an angle with the outlines of the core.

In the supposed cow, the characters are not so pronounced, but the keel of the inferior middle line is prominent nearly to the base. On one side of the keel is a long and strong sulcus, and on the other are two similar sulci, and a third short one. The superior face is strongly convex. In both cores the apex is broken away. I give the length of the larger core as I restore it.

Measurements of Core No. 1.

		MM.
Length on outside of curve, restored;		420
Length of fragment on inside of curve;		292
Diameters of core near base	vertical;	97
	transverse:	113
Depth of anterior face 100 mm. from base;		98
Depth of posterior face 100 mm. from base;		80

In life the apex of this horn-core was directed upwards, and it is evident that much more of the sheath was vertical than in *Bos americanus*, and may probably have been incurved at the apex.

The specimens which indicate this species were presented, together with the others from this locality and formation, to the University of Pennsylvania, by Mrs. Dr. B. F. Guerrero; and I am indebted to its authorities for the opportunity of examining and determining them.

EXPLANATION OF PLATES.

PLATE XXI.

Figs. 1–13. *Dinobastis serus* Cope; natural size.

Figs. 1–5. Superior dentition of left side from without; *1a–5a*, do. from inner side.

Fig. 6. Premolar; *a*, apical view.

Fig. 7. Fourth metacarpus from front; *7a*, inner side; *7b*, proximal extremity.

Fig. 8. Fifth metacarpus from front.

Fig. 9. Distal end of ? fifth metacarpus, from front.

Fig. 10. First phalange of fifth digit from front; *10a*, do. from distal extremity.

Fig. 11. Second phalange of fifth digit; *11a*, proximal extremity; *11b*, distal extremity.

Fig. 12. Ungual phalange from above; *12a*, from side.

Fig. 13. Head of femur, nat. size, from head; *a*, proximal view.

Figs. 14–16. *Canis indianensis* Leidy; natural size.

Fig. 14. Superior canine, from external side.

Fig. 15. Superior molars from below.

Fig. 16. Premaxillary bone with incisor from inside; *3a*, do. from front.

PLATE XXII.

Fig. 1. *Bos crampianus* Cope; anterior part of cranium with left horn-core from front and above; one-fourth natural size.

Fig. 2. *Bos crampianus* Cope; left horn-core from behind; one-fourth natural size.

Fig. 3. Do. section at middle of length.

Fig. 4. Section at 75 mm. from extremity.

Figs. 5–9. *Bos scaphoceras* Cope, left horn core; one-third natural size.

Fig. 5. Posterior view.

Fig. 6. Anterior view.

Fig. 7. Superior view.

Fig. 8. Section near base.

Fig. 9. Section proximad to first distal fracture.

THE STRUCTURE AND RELATIONSHIPS OF ANCODUS.

By W. B. Scott.

(Investigation aided by a grant from the Elizabeth Thompson Fund of the A. A. A. S.)

It might well seem that after the extensive investigations of Kowalevsky (No. 3) and Filhol (No. 1) any detailed description of the structure of this genus would be entirely superfluous. This, however, is far from being the case. The European specimens are made up from scattered bones of numerous individuals from widely separated localities (some of which bones would appear to be incorrectly referred to this genus), which by no means give a complete account of the osteology of the numerous Old World species. In the second place, it is very desirable to establish the points of resemblance and difference between the approximately contemporaneous species of *Ancodus* in America and Europe. In both continents the genus is confined to the (upper) Oligocene and has, therefore, but a limited range in time.

Hitherto little has been known of the American species of *Ancodus*, because of their rarity and the fragmentary condition of most of the specimens, since only in the recently identified Protoceras-beds are they at all common. Leidy was the first to announce the presence of the genus in this country; he described part of the dentition of a White River species under the name of *Hyopotamus americanus* (No. 5, p. 202). Marsh has given an extremely brief account of another species which he named *H. deflectus* (No. 6, p. 624). Both of these species are from the Titanotherium-beds at the base of the White River group. In 1893 I published a note on the manus of a species from the Protoceras-beds at the summit of the White River, showing that it possessed a well-developed pollex (No. 9, p. 165). Osborn and Wortman have recently described and figured a fine specimen of Leidy's species, which was collected in the Oreodon-beds, or middle division of the White River, and have also added to the American list a third species, *Ancodus* (*Hyopotamus*) *brachyrhynchus*, from the Protoceras-beds (No. 8, pp. 219–221, fig. 6, A and B). Up to the present time these comparatively scanty notices comprise the entire literature dealing with the American forms of the genus.

In the explorations of the White River beds of South Dakota by the Princeton Expeditions of 1893 and 1894, Mr. Hatcher discovered a number of finely preserved specimens of *Ancodus*, most of which were found in the sandstones of the Protoceras-beds, and which form the subject of the following description. These specimens display several interesting constant differences from those of Europe, as figured in the works of Kowalevsky and Filhol. The most important specimen comprises the skull and lower jaws with the greater part of the skeleton of an old individual which may be referred to the *A. brachyrhynchus* of Osborn and Wortman, though there are some differences, perhaps sexual, from the type of that species.

I. THE DENTITION.

The dentition differs but little from that of the European species from the Oligocene of Ronzon and Hempstead, and the formula is the same. Osborn and Wortman report that in their specimen of *A. americanus* the first upper premolar is absent, but it remains to be determined whether this is more than an individual character.

A. *Upper Jaw.*—The incisors are large, of hastate shape and nearly uniform size. Their arrangement is most like that of *A. leptorhynchus*, the median pair separated from each other by a considerable interval and presenting forward, the second and third nearly at right angles to the first, and presenting laterally. In *A. americanus* the incisors are implanted quite closely together, while in *A. brachyrhynchus* they are spaced well apart. The canine succeeds the lateral incisor after a short diastema, as is also the case in *A. velaunus*, not as in *A. Aymardi* or *A. leptorhynchus*, after a long interval. The crown is small, not much exceeding those of the incisors, but longer, more slender and pointed. It is much smaller than the great, curved, tusk-like canine of *A. leptorhynchus*, though not so much reduced as in the other two species of Ronzon, in which, according to Filhol, it has the form of p^1, though distinctly smaller. How far the differences between the supposed species of Ronzon, regarding the form and size of the canines, are sexual, cannot at present be determined, though it is significant that none of the specimens so far found in America have canines comparable in size to those of *A. leptorhynchus*.

The first premolar, when present, is a very small, simple tooth, implanted by two diverging fangs and with a compressed conical crown. Its position is subject to some variation in the different specimens of *A. brachyrhynchus*; in the type it is succeeded without interval by p^2, while in many others there is a short diastema between p^1 and p^2. From the canine it is separated by a moderate interval, and its position is thus very different from that found in any of the Ronzon species. In these, and especially in *A. leptorhynchus*, the diastema between the canine and p^1 is exceedingly long, and in the last-named species p^1 and p^2 are also widely separated. In *A. americanus*, which appears to have lost p^1, the interval between the canines and the premolars is much greater than in the other American species. The second premolar is relatively larger than in the Ronzon forms, except *A. velaunus*, having a considerably greater transverse diameter and a more prominent cingulum than is usual in them. It is of simple, conical form, with strongly developed internal cingulum, and implanted by three fangs; it may be in contact with p^3, or it may be separated from that tooth by a short space, which, however, is much less extended than in *A. Aymardi*. The third premolar is like the second, but larger and especially wider. A strong cingulum surrounds the crown, which is particularly prominent on the inner side and at one point broadens to form an incipient deuterocone. The fourth premolar is shorter and wider than the third and is made up, as in the selenodonts generally, of two transversely placed crescents; a prominent cingulum encloses the crown on three sides, being absent from the external face.

The molars increase regularly in size from $m^{\underline{1}}$ to $m^{\underline{3}}$; the former is protruded early and always shows more extreme abrasion than any other of the permanent teeth. The pattern of these molars is too well known to require any description, and differs in no point of importance from that found in the European species. There is a certain amount of variation in the development of the cingulum; in some specimens it is strongly marked on all sides of the crown except the internal, while in others it is interrupted upon the lingual faces of the two internal crescents (proto- and hypocones).

B. *Lower Jaw.*—The incisors have broad hastate crowns; the second is considerably the largest of the series, and the third the smallest. The canine follows the incisors without any diastema longer than the spaces which separate those teeth; its crown is shaped like the incisors and is smaller than the second of the series.

The premolars are of compressed conical shape, and of quite simple construction, except in the case of $p_{\overline{4}}$. In none of the specimens is the crown of $p_{\overline{1}}$ preserved, but the alveolus shows it to have been smaller than in *A. Aymardi*, and that it was supported upon a single fang. This tooth stands isolated; the space which separates it from the canine is slightly longer than that which divides it from $p_{\overline{2}}$. The latter is relatively small and is compressed, with sharp front and hind borders; faintly marked anterior and posterior fossæ are visible on the inner side of the crown and a postero-external one also, but there is no cingulum. This tooth is inserted by two roots, and in some specimens from the upper beds it is distinctly separated from $p_{\overline{3}}$, though not in others; it suffers much less from abrasion than the other premolars of the mandible. The third premolar is much larger than the second, particularly in the antero-posterior direction; it is like the latter in shape, but the inner fossæ are better marked and an incipient deuteroconid makes its appearance. The fourth premolar is the largest and much the most complicated of the series; deutero- and paraconids are distinctly developed and enclose a deep valley, forming an open crescent with the protoconid; the posterior fossæ are both enclosed, the outer one by the cingulum and the inner one by a ridge descending from the deuteroconid. Filhol's figures show this tooth to be of considerably simpler construction in the Ronzon species.

The molars require no particular description. As in the European forms the crown is composed of four incomplete crescents, which are remarkable for their height and the wide separation of their apices. The talon of $m_{\overline{3}}$ is very high and consists of a single element. The development of the cingulum varies in the different species and even in individuals.

II. THE SKULL. (Pl. XXIII, figs. 1–3.)

It is not practicable to compare in detail the elements of the skull in the American and European species, because of the imperfect preservation of the latter. In Europe entire skulls have been found only at Ronzon, and of these Filhol says: "Malheureusement, comme pour tous les autres crânes dont je parlerai dans la suite, l'écrasement subi par les os a été tel, qu' au milieu des lignes multiples correspondant aux points de rapprochement des éclats, il est absolument impossible de retrouver une trace bien définie de suture." (No. 1, p. 99.) Comparison between the skulls of the species of *Ancodus* found in the Old and New Worlds, respectively, must therefore, for the most part, be confined to the general form and proportions.

In the fossils from Ronzon figured by Kowalevsky and Filhol the skull is remarkably long, low, and narrow. This elongation does not affect the cranium so much as the face, for the orbit is placed rather far back, with its front margin over m^3, while in *Oreodon* it is over m^1. The muzzle in front of p^2 is especially concerned in the elongation, and in *A. leptorhynchus* it reaches an astonishing degree of length and slenderness, while it is least extreme in *A. velaunus*. The length of the muzzle is materially increased by the elongation of the premaxillaries, which project much in front of the canine. The cranium is not very long, as is indicated by the position of the orbits, and is narrow and of small capacity. The occiput is low and wide, but its upper portion is not very concave and does not project backward very strongly. The zygomatic arch is rather slender; it pursues a nearly straight course and the postorbital processes of the frontal and jugal, especially the latter, are but feebly developed, leaving the orbit widely open behind. The anterior nares are small and very oblique in position, sloping downward and forward. The posterior nares have different positions in the different species, but are long and narrow in all; they are farthest forward in *A. Aymardi*, extending to the hinder border of m^2. In *A. leptorhynchus* they are farther back, the front margin being opposite to the posterior half of m^3, while in *A. velaunus* it is entirely back of the molar series. The palatal notches are deeply incised. The auditory bullæ are but slightly inflated. The mandible has a slender and nearly straight horizontal ramus and a large prominent angle with thickened border. The condyle is raised relatively little above the level of the molars and the coronoid process is low and of triangular shape. The masseteric fossa is not very deeply imprinted on the jaw.

The American species differ from the French in almost all the characters which have been enumerated. In *A. americanus* the muzzle is greatly elongated, but little less so than in the shortest-headed of the Ronzon species, *A. velaunus*, but *A. brachyrhynchus* has a face of only moderate length and neither is at all comparable in this respect to *A. leptorhynchus* or even *A. Aymardi*. The cranium is broader, more rounded and capacious, and the postorbital constriction less profoundly marked. The forehead is much wider and the postorbital processes of the frontals considerably longer. The zygomatic arch is somewhat heavier and not so straight, curving more downward in its course to the orbit. The occiput is low and broad, but the posterior surface of the supraoccipital is deeply concave and overhanging and projects beyond the condyles much more decidedly than in *A. velaunus*, showing a tendency to the formation of wing-like processes, such as occur in the oreodonts. The anterior nares are small and have a less oblique position than in the European species, presenting more directly forward. The posterior nares open very far back, the palatines being in contact for some distance behind the line of the molars and forming a narrow tube suggestive of aquatic habits. The tympanic bullæ are decidedly larger than in any of the species figured by Filhol and of quite a different shape. The mandible has a higher coronoid process, of a shape entirely unlike that of any of the French species, more resembling that found in the ruminants, with a deep and regularly curved sigmoid notch; the masseteric fossa is deeply impressed. The size and shape of the coronoid process and the relative length and slenderness of the horizontal ramus of the mandible vary considerably in the different American species.

The White River specimens of *Ancodus* permit an exact determination of most of the bones of the skull, as the European ones do not. A careful description of these elements is by no means out of place, because the skull structure of the *Anthracotherium* group is still little understood and much depends upon an accurate knowledge of it.

The basioccipital is not broad, but heavy, and subcylindrical in shape, tapering somewhat toward the anterior end. Near the condyles no tubercles are developed, but a large pair, with roughened surfaces and of oval shape, appear on the bone between the auditory bullæ, and are separated from each other by a shallow groove. On the sides of the basioccipital are depressions to accommodate the largely inflated tympanics. The exoccipitals are low and very broad; in the median line the cerebellar fossa forms a broad convexity, on each side of which is a shallow depression, while the wide lateral portions are slightly concave in the transverse direction. The foramen magnum is relatively small and of subcircular outline. The condyles are wide, but of no great vertical height, and they do not project so much below the cranial basis as they do in *A. velaunus*. They are separated below by a considerable groove and their articular surfaces end abruptly, not being continued forward upon tubercles of the basioccipital, as is so frequently the case in ruminants. The paroccipital processes are ruminant in position, suilline in shape; they stand well in advance of and exterior to the condyles, with which they are not connected by ridges. Proximally the processes are very broad, but they rapidly contract to slender and elongate prismatic rods. The paroccipital is in contact with the tympanic bullæ at two points, between which is the opening of the stylomastoid foramen. A groove on the anterior face of the process marks the continuation of this canal. The supraoccipital is rather high and narrow; its posterior surface is concave in the middle, with two smaller and shallower lateral depressions which are separated from the median one by ridges. This portion of the occiput is wider, relatively, than in *Oreodon* and overhangs considerably behind the plane of the condyles, forming the hindermost portion of the skull. The wing-like processes of the supraoccipital are less developed than in *O. Culbertsoni*, more so than in *O. gracilis.* The upper margin of the bone is arched regularly from side to side and slightly notched in the median line. In this region, also, is considerable development of diploëtic structure, separating the two tables of the bone. Even in young specimens it is by no means easy to determine the position of the sutures between the supraoccipital and the parietals; the former appears, however, to take part in the formation of the cranial roof to about the same extent as in *Oreodon* and other primitive artiodactyls. Comparatively little of the lambdoidal crest is formed by the occipital bones.

The basisphenoid is a heavy, subcylindrical bone, shaped much like the basioccipital, but narrower and with an uninterrupted ventral surface. Its junction with the presphenoid is concealed by the vomer. Both the basisphenoid and the basioccipital, aside from the large tubercles on the latter, have very much the form and proportions seen in *Oreodon.* The alisphenoid is well developed; its ascending portion is narrowed at the base by the foramen lacerum anterius and foramen ovale, which are placed quite near together, but above these it widens out. The pterygoid process is stout, but of no great vertical height; it has the peculiarity of extending to the auditory bulla, with which it comes in contact and thus encloses the foramen lacerum medium in a deep fossa. This is an unusual feature. The presphenoid is not visible, being covered up by the vomer, and the limits of the orbitosphenoid cannot be made out with certainty in any of the specimens.

As in the primitive artiodactyls generally, the parietals are extremely long and make up most of the roof of the cerebral fossa. For the greater part of their length they unite to form a high, thin sagittal crest, which is gently arched from before backward, rising both from the forehead and the lambdoidal crest; anteriorly it bifurcates into two low and slightly roughened temporal ridges. The parietals themselves likewise diverge at this point and receive between them a tongue-shaped prolongation of the frontals. For most of their course the parietals are narrow, the large size of the squamosals preventing any great expansion laterally. In front of the squamosals, however, they become much wider and send down processes to meet the alisphenoids.

The squamosal is large and forms a great part of the side wall of the cranial cavity; its prominent, compressed, and rounded hinder margin makes up most of the lambdoidal crest. The junction of the exoccipital and squamosal almost entirely excludes the periotic from the surface of the skull, but inferiorly the two elements diverge slightly, forming a triangular space, in which a narrow strip of the periotic is exposed. The mastoid process is rudimentary and forms a mere tubercle. The posttympanic process of the squamosal is closely applied to the paroccipital process and extends below the tube of the auditory meatus. The postglenoid process projects strongly backward and is separated only by a narrow space from the posttympanic. This region of the skull is very similar indeed to that of *Oreodon* and especially of *O. gracilis,* in which the postglenoid process inclines more posteriorly than in *O. Culbertsoni.* The glenoid cavity is large, extending nearly the full width of the zygomatic process, and is plane transversely; antero-posteriorly it is made concave by being continued upon the postglenoid process. The latter is long, stout, and tapering distally to a blunt point, and thus has an entirely different shape from that of *Oreodon*, in which it is broad, massive, and of uniform height. The zygomatic process is very like that of *Oreodon*; its root is much extended in the fore-and-aft direction, reaching over the auditory meatus and posttympanic process, its raised outer border passing into and continuous with the lambdoidal crest. The zygomatic process itself is thin and compressed, but has considerable vertical depth; it arches downward and forward, pursuing a less straight course than in the Ronzon species. Anteriorly the process tapers to a blunt point which is received into a notch of the jugal beneath the orbit. The zygoma is not so long as in *Oreodon*, which has the orbit considerably farther forward, but in other respects the resemblance is close. In *Oreodon* the contact of the zygomatic process with the jugal is shorter and hence the former is less attenuated anteriorly.

The jugal is quite a massive bone; beneath the orbit it is deep vertically, but gradually tapers backward, where it passes beneath the zygomatic process. It is relatively longer than in *Oreodon*, and is not separated from the glenoid cavity by so wide an interval as in that genus. The postorbital process, though short and not nearly reaching that from the frontal, is nevertheless more conspicuously developed than in the European species. The jugal does not appear to be much expanded on the face in front of the orbit.

As in *Oreodon* the lachrymal is large and forms much of the anterior boundary of the orbit, but there is no such pit or depression as occurs in that genus. The foramen is single and is placed within the edge of the orbit.

The frontals together make up a short, broad, lozenge-shaped area. Posteriorly they send back narrow prolongations, which are received between the parietals and form a very limited part of the roof of the cerebral chamber. Anteriorly they are deeply notched to receive the nasals, while the nasal processes are long and have extensive sutures with the maxillaries. Owing to the prominence of the orbits, the forehead is very wide, much more so than in *A. velaunus*, and is slightly concave transversely, not being inflated and rounded by sinuses, as is the case in *Oreodon*. As in the latter, the supraorbital foramina are placed near the median line, but the vascular grooves which run forward from them are longer and more distinctly impressed. The postorbital process of the frontal is considerably longer than in *A. velaunus*, but the orbit remains widely open behind. The temporal ridges encroach but slightly upon the frontals.

The nasals are very long, participating in the great elongation of the muzzle; they are broadest behind, narrowing anteriorly, and are somewhat convex from side to side. The anterior ends project little, if at all, beyond the premaxillaries and are notched in the middle.

The premaxillaries have a relatively great antero-posterior extension, the incisors being well spaced apart and arranged in nearly the same fore-and-aft line. The alveolar portion is solid and massive, and the ascending process is long, low, and broad, having an extensive suture with the nasal. There is no distinct palatine process, and the premaxillary spine is a slender cylindrical rod, which, owing to its fragility is very generally missing from the specimens. The anterior nares are notably small, but they are less oblique in position and present more directly forward than in *A. velaunus*. The incisive foramina are very narrow, but quite elongate.

The maxillaries are of great length, the extraordinary elongation of the muzzle being due principally to them. The alveolar portion is low, in correspondence with the very brachyodont character of the molars, as is also the vertical plate which forms the side wall of the nasal chamber. This plate is, however, considerably higher than in the Ronzon species. How far the very low maxillaries and, consequently, very depressed face of the latter are due to the crushed condition in which they are found, it is difficult to say, but the greater height of these bones would appear to be a constant character of the American species. The face is constricted in front of p^4, and again and more decidedly in front of p^1. The masseteric ridge is very prominent and is continued forward to the infraorbital foramen, which opens above p^4. Long as the maxillary is, its contact with the nasal is a rather limited one, the sutures with the premaxillary and frontal occupying so much of the length of the nasal. The upper margin of the maxillary descends anteriorly, its vertical height decreasing toward the front. The palatine processes are long, narrow, and of nearly uniform width throughout, the inner sides of the two molar-premolar series forming straight and nearly parallel lines. The bony palate is slightly concave from side to side and almost plane from before backward. The palatal notches are deeply incised, but less so than in *A. leptorhynchus*. The maxillary is not continued so far behind the last molar as in the latter species, nor is it so broadened and inflated at this point as in *A. velaunus*. The posterior palatine foramina occupy the same advanced and unusual position as in *Oreodon*, namely, opposite p^4.

The palatines are united together for a long distance, which shifts the posterior nares much farther back than in any of the European species, so far as the latter are known, though *A. velaunus* approximates the American type in this respect. The tubular shape of the canal with its narrow opening behind recalls that of *Hyænodon* and might suggest aquatic habits, were it not for the somewhat similar arrangement which occurs in the deer *Cariacus*, which, of course, is altogether terrestrial.

It is somewhat surprising to find the vomer produced so far backward, extending, as it does, nearly the entire length of the posterior narial canal and plainly visible from below, as is also true of *Cariacus*. It is not, however, high enough in this part of its course to reach the palatines and thus completely divide the passage into two chambers, as is the case in the modern genus.

The tympanic is inflated to form a large auditory bulla, considerably more so than in the European species and of a somewhat different shape. The form is oval, with a marked depression on the ventral surface, internal to the median line. This gives it a very different appearance from the regular, almost spherical bulla of *Eporeodon.* As in that genus, the bone is thin, though dense, and the cavity is free from cancellated tissue. The auditory meatus is a quite elongate and incomplete tube, lacking the dorsal wall.

The cranial foramina cannot be determined in the French skulls, but in the White River specimens they are nearly all plainly shown. The optic foramen is small and placed rather far forward. The foramen lacerum anterius is quite large and irregular, somewhat as in the deer, though smaller. The foramen ovale penetrates the root of the pterygoid process of the alisphenoid, which extends to a contact with the auditory bulla. The foramen lacerum medium is concealed in the deep space enclosed between the bulla and the alisphenoid. The foramen lacerum posterius is a narrow slit between the auditory bulla and the basioccipital, while the stylomastoid foramen is large and conspicuous. The glenoid foramen is rather internal to than behind the postglenoid process. The condylar foramen occupies much the same position as in *Cariacus*, but lies a little farther forward, and hence is not so much concealed by the overhanging of the condyle. The posterior palatine foramina are not placed in the neighborhood of the maxillo-palatine suture, but perforate the palatine plates of the maxillaries on a line with the last premolars. They occupy the same position in *Oreodon* and in *Protoceras* they are even more advanced. The infraorbital foramen is large and opens above $p^{\underline{1}}$, while the supra-orbital foramina open on the surface of the skull near to the median line.

The mandible displays considerable differences among the various specimens from the upper beds. In one individual the horizontal ramus is thick and heavy, but quite shallow vertically, and thus appearing to be quite slender, when viewed from the side. The symphysis is procumbent, and its lower border is raised but little above that of the rest of the horizontal ramus. The coronoid process is rather short and slender, very decidedly recurved, and separated from the condyle by a broad sigmoid notch. In other specimens, which may represent a different species, the horizontal ramus is considerably deeper and heavier, and the lower margin rises abruptly to the procumbent chin, the inferior margin of which lies at a considerably higher level than that of the other part of the ramus. The ascending ramus is higher, the angle more prominent, the coronoid process much higher and broader and less strongly recurved, which renders the sigmoid notch narrower and less deeply incised. The angle is more prominent and more produced below the level of the horizontal ramus, and the masseteric fossa is larger and deeper. In all the specimens the condyle is much extended transversely, and toward the internal side the articular surface is reflected over upon the posterior side, to form a facet for the postglenoid process of the squamosal. In aged individuals the two mandibular rami are sometimes ankylosed.

Oreodon has a mandible of similar type to that of *Ancodus* with manifold differences of detail. Of these the most striking is the very much shorter horizontal portion, without diastemata, corresponding to the relatively great shortening of the whole facial region. The angle projects more abruptly back of the condyle, but descends less below the inferior border of the horizontal ramus. The coronoid process is less elevated and recurved than in the American species of *Ancodus*, more than in the European, and the condyle is much less extended transversely and especially on the outer side. The symphyseal region is much more steeply inclined and less procumbent. In all of these particulars the later oreodont genus, *Merycochœrus*, presents a decidedly closer approximation to *Ancodus* than does *Oreodon* itself, though never attaining such an extreme elongation of the face.

II. THE VERTEBRAL COLUMN.

The *atlas* differs from that of *Oreodon* in being proportionately longer and less extended transversely. The anterior cotyles are separated dorsally by a wide and deep emargination of the neural arch; the latter is quite strongly convex from side to side, and the neural spine is represented by a prominent rugose tubercle. A lyrate area, formed by ridges, encloses the spine and descends abruptly at the sides, which are perforated by foramina for the first pair of spinal nerves. The transverse processes are not greatly extended laterally, nor do they reach so far back of the surfaces for the axis, as is the case in *Anoplotherium*, though their shape is more like what we find in the latter genus than that in *Oreodon*. So far as I can determine, the transverse process is not perforated by the vertebrarterial canal. The facets for the axis are large and but little oblique in position, presenting more backward than inward.

If Kowalevsky has correctly referred to *Ancodus* the axis from Puy (Ronzon), which he has figured (No. 3, Pl. XXXIV, fig. 7), then the American species of the genus differ very radically from the European with regard to the character of this bone. There can, however, be but little doubt that Kowalevsky's specimen has been erroneously identified, and that it belongs to some very different genus, probably a perissodactyl (*Ronzotherium?*). In *A. brachyrhynchus* the axis has a long, broad, and much depressed centrum, which is but feebly keeled upon the ventral side and has no hypapophysial tubercle. The anterior cotyles for the atlas are very broad, extending out laterally much beyond the rest of the centrum, but, at the same time, they have no great vertical height and do not reach far enough upward to enclose more than a small part of the neural canal. The articular surfaces of these cotyles are saddle-shaped, slightly concave transversely and convex dorso-ventrally. The odontoid process is, in the later species, of the shape which might almost be called the White River ungulate type, so many different groups found in that formation having acquired it, e. g., *Mesohippus*, *Oreodon*, *Agriochœrus*, *Ancodus*, *Poëbrotherium*, *Protoceras*. It is neither conical nor spout-shaped, but intermediate between the two, being broad but depressed and of small vertical diameter; the ventral surface is convex and the dorsal nearly flat; the free margin is gently curved and the process gradually contracts anteriorly until it ends in a blunt point. I have elsewhere shown the great probability of the independent acquisition of this character by *Mesohippus*, *Oreodon*, *Poëbrotherium*, *Protoceras*, and *Gelocus*, and that it is correlated with increased length and curvature of the neck. That *Ancodus* should be added to this list of parallelisms is obvious from the comparison of the process in the species from the lower beds with those from the upper sandstones.

In the American Museum of Natural History, New York, is preserved a fragmentary skeleton of *A. americanus*, from the Metamynodon-beds (or middle Oreodon-beds of the White River), for an opportunity to study which I am indebted to the kindness of Messrs. Osborn and Wortman. It is in many ways different from the skeleton of the large *A. brachyrhynchus*, which forms the principal subject of the present description. In *A. americanus* the neck is shorter than in *A. brachyrhynchus* and the axis especially is different; it is smaller and, in particular, shorter (33 : 46) with lower, but relatively wider atlanteal surfaces, which present more directly forward. A more important difference is in the character of the odontoid process, which is conical, though slightly depressed, the transverse diameter somewhat exceeding the dorso-ventral. The ventral face of the process is flattened and much less strongly convex than the dorsal, which is the reverse of the shape in the later species. The odontoid has an upward as well as a forward direction and is longer and more slender than in the pigs.

The posterior face of the centrum is wide, depressed, concave, and oblique in position. The neural arch is broad and high, enclosing a large canal, and the neural spine resembles that of *Agriochœrus*, forming a great plate with curved and slightly thickened border; its anterior end projects over the atlas in the form of a blunt hook. The postero-superior angle is broken away in the only available specimen, preventing the determination of its exact shape, but the thickening at this point indicates a posterior rib-shaped prolongation, such as occurs in *Dicotyles* and *Oreodon*, though not in *Agriochœrus*. The postzygapophyses are large and prominent and present directly downward. The transverse processes diverge widely from the centrum, projecting outward more than backward, but with their free ends recurved somewhat toward the median line. These processes are obscurely trihedral in shape and are proportionately heavy; they are perforated by the vertebrarterial canal, and their anterior ends are connected by low ridges with the articular facets for the atlas.

The other cervical vertebræ have moderately elongate and heavy, opisthocœlous centra, with obliquely set faces; they have very faintly marked ventral keels, and the hypapophysial tubercles are either rudimentary or altogether absent. Of the cervical series the 7th is the shortest, and next to that the 6th. In relative length the neck considerably exceeds that of *Sus* and even that of *Oreodon*. In the case of the latter genus the comparison cannot fairly be made with the skull, on account of the extreme shortening of the face, which in *Ancodus* is as extremely elongated. But taking the humerus as a standard of comparison, the neck is proportionately longer in *Ancodus brachyrhynchus* than in *Oreodon*. The neural arches are broad and low, and the pedicels of the neural arches are not perforated for the exit of the spinal nerves, as they are in the pigs. These pedicels have very little antero-posterior extent, while the zygapophyses are very prominent; those of the opposite sides of the same vertebra are very widely separated, while the anterior and posterior processes of the same side are brought close together. This is in consequence of the great breadth of the neural arches, together with their shortness in the fore-and-aft direction, their length being considerably less than that of their centra. The zygapophyses are very large, have nearly flat faces, and present almost directly upward and downward, with but little obliquity of position. The neural spines increase in height successively from the 3d to the 7th. On the 3d vertebra the spine forms a low and inconspicuous ridge, while on the 5th it has attained considerable height and thickness. The transverse processes most resemble those usual among the Pecora, aside from the differences caused by the smaller elongation of the centra. On the 5th the inferior lamella is very large and distinctly differentiated into two parts, much as it is in *Oreodon*, and the diapophysial element is as conspicuously developed as on the 6th. The latter has a still larger inferior lamella, with thick and roughened free margin and relatively short diapophysis. The last cervical is, as usual, without any pleurapophysis, and the transverse process is in the form of a long, stout bar, with slight upward curvature. All the cervicals, except the atlas and the 7th, display the vertebrarterial canal.

The *thoracic vertebræ* must have numbered at least thirteen, since that many ribs of the right side are in position in one of the specimens. The nine anterior thoracic vertebræ have centra of almost uniform length, which quite strongly resemble those of the deer. The 1st and 2d have the broadest and most distinctly keeled centra. The spines are compressed, slender, inclined very strongly backward and are rather short, as compared with those of *Sus* or of the larger Pecora. The transverse processes are of no great length, but they have very large facets for the tubercles of the ribs.

The *lumbar* region must have contained at least six vertebræ, that many being preserved in the New York specimen of *A. americanus*, already referred to, which indicates that the number of trunk vertebræ cannot have been less than nineteen, though the number of thoracic and lumbar vertebræ was doubtless subject to specific variation. The first lumbar has a centrum which is long and deep, but slender, trihedral and contracted in the middle; the faces are slightly opisthocœlous. Passing backward, the centra become more and more broadened and depressed, a change which reaches its maximum in the sixth. In spite of this progressive difference of shape, the first five vertebræ have centra of almost uniform length, while the 6th is considerably shorter than the others. The processes are nearly all broken away, but enough remains to show that the neural arches are low and short antero-posteriorly, and that the transverse processes are very broad and thick.

Of the *sacrum* the first vertebra is preserved in the same skeleton, which has yielded the lumbars. The anterior face of the centrum is very broad and low and the posterior face much narrower and lower still. The neural canal is likewise very low, but wide. The pleurapophyses are very large and heavy, both vertically and transversely. Apparently, the pelvis was borne entirely by this vertebra and had no contact with the second; this, however, is uncertain. From the character of the sacrum it may be inferred that *Ancodus* did not possess a very long or stout tail.

No caudal vertebræ are preserved in the collection.

With the exception of the atlas, which is longer and less broadened transversely, all of the vertebræ which have been described are extremely like those of *Oreodon*. They are, of course, much larger than in that animal, but their construction is essentially similar, while their resemblance to the vertebræ of the pigs is but remote.

III. THE RIBS AND STERNUM.

The ribs are somewhat more modernized than those of *Oreodon*, which are remarkable for their slenderness, though the difference is in some degree to be correlated with the great difference of size in the two genera. In *Ancodus* the first rib is short and nearly straight, the thorax being very narrow in front. Behind this point the ribs rapidly lengthen and become more and more strongly arched outward; from the 3d to the 11th they are very long and indicate a capacious thorax. The first eight ribs are rather slender proximally, but for the distal two-thirds of their length they are much broader and more flattened than in *Oreodon*, though less so than in *Anoplotherium*. The 9th is more slender, while the posterior ones become decidedly so. The tubercles are remarkably large and prominent up to the 11th.

Of the sternum the three anterior segments are preserved. The first segment is not entirely like that of either the Suina or the Pecora. In the former it is "compressed and keeled, the articular facets for the first pair of ribs are close together on its upper surface; but the mesosternum is broad and flat, the first segment being compressed in front, broad posteriorly." In the Pecora "the presternum is narrow, rounded in front, and bearing the first pair of sternal ribs close to its apex. The succeeding pieces gradually widen, the posterior segments of the mesosternum being square, flat, and rather massive; they are hollowed at the middle of their lateral borders." (Flower, No. 2, pp. 96–97.) In *Ancodus* the shape of the presternum is most like that of the ruminants, but it is much narrower, more compressed, and less expanded at the free end. The facets for the attachment of the sternal ribs are not clearly shown, but appear to have been near the apex. The mesosternum is quite like that of the Pecora, save that the lateral borders are not so deeply emarginated. The sternum of *Oreodon* differs in no important respect from that of *Ancodus*.

IV. THE FORE-LIMB.

The *scapula* resembles, with some differences, that of the European species which Kowalevsky has described: "The general aspect of this new specimen presented a great similarity to the one figured from Hordwell [i. e., of *Diplopus*]; beginning from the neck, the bone broadened rapidly to its upper and broken extremity, and acquired the same remarkable breadth which is so conspicuous a feature of the scapula of *Diplopus*. The spine of the scapula was also very oblique, inclining outwards, as in the scapula figured in Plate XXXV. The fossa glenoidea had precisely the same exceedingly circular outline as is seen in the figured scapula; the coracoid process did not project much and was recurved in the same characteristic manner. On the outer margin of the neck, however, where I found a deep fossa in *Diplopus*, the scapula from Puy presented only a flattening." (No. 3, p. 32.)

A. brachyrhynchus, left scapula, about ¼ natural size.

In *A. brachyrhynchus* the scapula is relatively much higher and narrower than in *Diplopus*, or even than in *Anoplotherium*, and is proportioned very much as in *Oreodon*. The neck is narrower and more slender than in *Diplopus*, and there is a more distinct coraco-scapular notch; the spine is not so high or so thick, the acromion much shorter, not extending so near to the glenoid cavity, and the coracoid is much smaller. The coracoid border forms a thin edge and curves convexly forward and upward from the coraco-scapular notch. The glenoid border is nearly straight and somewhat elevated and thickened; its divergence from the neck is at a moderate angle. The suprascapular border is also nearly straight, and curves gently into the coracoid border, while making an acute angle with the glenoid border. The general form and proportions of the blade thus approximate quite closely to those which we find in the ruminants, and depart in a marked way from the type of scapula which Kowalevsky has described from Ronzon.

As in the primitive artiodactyls generally, the spine is placed almost in the middle of the blade, which is thus divided into pre- and postscapular fossæ of nearly equal width. The spine terminates well above the glenoid cavity; it is high, but compressed and thin; the acromion is short, not overhanging the neck very far, nor descending to the level of the glenoid cavity, and ends in a roughened tubercle. The glenoid cavity, which in *Anoplotherium* is very oval, departs very little from the circular form, the antero-posterior diameter only slightly exceeding the transverse. The articular surface is a shallow concavity. The coracoid is a large, compressed and prominent tubercle, but not hook-like or recurved. The scapula of *Oreodon* agrees with that here described in every particular except size, while the differences from that of the European species of *Ancodus* are obvious.

The *humerus* (Pl. XXIV, fig. 5) differs considerably from the one which Kowalevsky has figured as belonging to *Diplopus*, and more resembles that of *Oreodon*. The head is rather prominent and convex and projects quite strongly backward. The external tuberosity is very large and massive, rising far above the level of the head, and extending across the whole anterior face of the bone; its internal end forms a short, blunt hook, which overhangs the broad bicipital groove rather more than in *Oreodon*. The internal tuberosity is small and compressed, but rugose. The shaft is short and heavy; proximally it has a great antero-posterior diameter, which gradually diminishes downward; the deltoid ridge is prominent and descends low upon the shaft. The distal part of the shaft is transversely expanded and depressed, though not perforated, by the supratrochlear fossa; the supinator ridge is well developed. The trochlea differs from that of *Diplopus*, *Anoplotherium* and *Oreodon* in the narrowness of the intercondylar or median ridge, which is not the rounded, bulging protuberance found in those genera; in other respects it agrees best with that of *Oreodon*, not possessing the downward, flange-like prolongation of the internal portion, which occurs in *Diplopus*, and to a much more marked extent in *Anoplotherium*. The internal epicondyle is exceedingly prominent, even larger than in *Oreodon*, and forms a great, swollen rugosity. The humerus of *Agriochœrus* offers but little resemblance to that of *Ancodus*, having become differentiated in a way extremely like that of certain creodonts, particularly of *Mesonyx*.

The *radius* (Pl. XXIV, fig. 6) differs from that of *Oreodon* in several respects. As in that genus, the trochlea for the humerus is divided into three facets, the middle one of which is, however, much narrower than in *Oreodon*, the inner one wider, and the outer one different in not descending obliquely forward. Of the proximal facets for the ulna the external one is a deep concavity. The head contracts sharply to the shaft, the upper portion of which is slender and rounded, but continually enlarging as it descends, becomes both broad and thick toward the distal end. The shaft is strongly bowed forward, but the radio-cubital arcade is short and narrow, because the ulna has a very similar curvature. In *Oreodon* the shaft of the radius is much more decidedly slender and subcylindrical throughout. In *Ancodus* the distal end is quite massive and heavy, and has a broad tendinal sulcus on its anterior face, enclosed by elevated ridges. The carpal facets for the scaphoid and lunar are obscurely separated; that for the former is the larger, convex transversely and concave antero-posteriorly, more oblique in position, and is reflected upward as a broad band upon the postero-internal angle of the bone. The lunar facet stands at a somewhat higher level than the scaphoid; it is broad and concave in front, narrower and convex behind. The distal ulnar facet is large and deeply concave.

The radius referred to this genus by Kowalevsky differs in several respects from the one here described. The outer proximal ulnar facet is convex, not a deep depression; the carpal facets are broader, less extended in the dorso-palmar direction, less oblique in position with reference to the transverse axis of the distal face, and more distinctly separated.

The *ulna* is but little reduced and proximally is heavier than the radius. The olecranon is very large, but low and erect, projecting backward but very little, while the antero-posterior diameter is relatively very great. The summit of the process is straight, thickened, and somewhat overhanging to the radial side, and the tendinal sulcus is deeply incised, with greatly elevated internal margin. The sigmoid notch is low and, except proximally, the articular surface for the humerus is confined to the inner side; there is also a minute distal external facet for the humerus. The shaft is of the laterally compressed, trihedral shape found by Kowalevsky in the species from Ronzon; it diminishes in size inferiorly, but expands again above the distal end to fit the corresponding depression on the radius. The distal surface for the cuneiform is narrow and convex, passing behind into a large flat facet for the pisiform. This ulna is, on the whole, much more like that of *Oreodon* than that of *Anoplotherium*, but the olecranon is relatively lower, and the shaft has a stronger curvature toward the anterior side. In Kowalevsky's specimen the olecranon is not so heavy and deep antero-posteriorly, but higher, and projects more strongly backward than in the American forms.

The *manus* (Pl. XXIV, fig. 7) has already been described in detail by Kowalevsky, but it is necessary to go over the ground again, because his material was very imperfect, being taken from many different individuals and widely separated localities, and also because of certain differences which obtain between the American and European species.

The hand displays many and significant resemblances to that of *Oreodon*, and the differences, though not unimportant, are of hardly more than family rank. The carpus is broad and, as in the ancient artiodactyls generally, relatively very high. The scaphoid is high, narrow, and deep, differing in shape from the scaphoid of *Oreodon*, which is of nearly cubical outline. The radial facet is very slightly concave and oblique, descending toward the inner side, but not reflected down upon the dorsal face of the bone, as it is in Kowalevsky's specimens and in *Oreodon*. The lunar facet is single and confined to a band, which runs along the proximal border of the ulnar side. The distal surface is occupied by the facets for the magnum and trapezoid; the former is slightly convex and is not prolonged backward into a concave surface, as it is in *Oreodon*. The facet for the trapezoid is large and concave, situated behind, as well as internal to that for the magnum, while the surface for the trapezium is very small and confined to the postero-internal angle of the distal side. As in the Ronzon species, "the posterior extremity of the scaphoid is elongated into a thick, recurved portion, which bends inside the carpus."

The lunar is quite different from that of the European species in the presence of an extension of the proximal portion toward the ulnar side to meet the unciform. The radial facet is oblique, inclining toward the internal side as it passes backward; it is broad and convex in front, where it also rises towards the ulnar side, and is narrow and concave behind. This facet differs from the corresponding one in *Oreodon* in the smaller anterior convexity and larger posterior concavity, as well as in the obliquity of its position. The distal beak is longer than in the European forms, shorter than in *Oreodon*, and is not shifted so far toward the radial side as in the latter. The magnum facet is considerably narrower than that for the unciform, and, as in *Oreodon*, is rather lateral than distal in position, but differs from the condition found in that genus in being concave rather than convex in front and in making a more open angle with the unciform surface. The latter is large, oblique in position, and concave in both directions.

The cuneiform is high and transversely extended, but has little dorso-palmar depth. The ulnar facet is slightly concave antero-posteriorly and of irregular shape; it is high on the inner side, low on the outer, where the height of the bone is much reduced. The pisiform facet is a large and simple, oval concavity, which is not continuous with the surface for the ulna. On the radial side of the cuneiform are two facets for the lunar; the proximal one is small and confined to the dorsal margin, while the distal one occupies the whole depth of the bone. The unciform facet is rather small, not taking up the whole distal surface of the cuneiform, and is rather concave. The cuneiform of *Oreodon* is lower, but deeper antero-posteriorly than that of *Ancodus*, and more cubical in shape. The pisiform is not preserved in any of the specimens.

The trapezium is relatively well developed; it is narrow and compressed, but quite high and deep. In view of the comparatively large size of the pollex, it is somewhat surprising to find that the trapezium has but a small facet for the scaphoid, and articulates more extensively with the first and second metacarpals and with the trapezoid. The surface for the trapezoid is situated rather high up on the ulnar side of the trapezium, and below it is a small facet for the second metacarpal. The distal facet for mc. I is narrow but deep, convex and broader in front, concave and contracted behind; the distal end extends a little below the level of the trapezoid. The trapezium has not been found in the European species, but, as Kowalevsky showed, the facets on the trapezoid and mc. II demonstrate its presence in these forms. The trapezium occurs also in the oreodonts, but its shape is known only in *Mesoreodon* and *Merycochœrus*, in both of which genera the pollex has disappeared and the carpal is reduced to a mere nodule.

The trapezoid is narrow, but much extended antero-posteriorly, thus reversing the proportions found in *Mesoreodon*. The proximal end bears a rounded, convex facet for the scaphoid and the distal end a narrow, saddle-shaped one for mc. II. On the ulnar side is a plane surface for the magnum, which occupies the entire height of the bone, but only about one-half of its dorso-palmar depth. The trapezoid of the European species does not differ in any important respect from that of the American.

The dorsal face of the magnum, exposed when all the carpal elements are in position, is broad and low, but toward the palmar side it rises to a considerable height, though not forming a well-defined, rounded head. Posteriorly the magnum is provided with a long, stout, and somewhat decurved hook. The scaphoid facet takes up most of the proximal side; it rises toward the ulnar side, where its junction with the lunar facet forms a high crest. It also rises gradually toward the palmar side, and is transversely concave throughout; there is, however, a very faint indication of a dorsal concavity and palmar convexity. The lunar facet is lateral rather than proximal; in front it is narrower and nearly plane, descending almost to a junction with the surface for mc. III, while behind it rises to form a broad convexity, which is more proximal in position, and is reflected well over upon the palmar side of the bone. Distally there is a large saddle-shaped surface for mc. III, as well as a narrow, plane facet for mc. II upon the radial side.

The magnum of *Oreodon*, while essentially like that of *Ancodus*, has still many points of difference. (1) There is a distinctly developed head, and the scaphoid facet is very clearly divided into dorsal concavity and palmar convexity. (2) The lunar facet has a more completely lateral position, and does not broaden out behind to anything like the same extent. (3) The posterior hook is very much smaller. While these differences are very marked, the resemblances are even more important. In the carpus of both genera a displacement of the magnum toward the radial side and a tendency of the lunar to rest entirely upon the unciform are obvious, but this displacement has been carried farther in the oreodonts than in *Ancodus*. In *A. americanus* the shifting of the magnum has proceeded farther than in *A. brachyrhynchus*, and the contact with the lunar is more entirely lateral. The distal beak of the lunar is more pronounced, and the resemblance to the lunar of *Oreodon* more complete. In the European species of *Ancodus* the magnum has an even less distinctly marked head than in the American, and the relation of the proximal facets is reversed, that for the lunar being larger than that for the scaphoid. The palmar hook is broader and more massive. Kowalevsky calls attention to the perissodactyl character of this bone. (See Monographie der Gattung Anthracotherium; Palæontographica, XXII, pp. 303–4, Taf. XI, fig. 39–42.)

The unciform is the largest bone in the carpus, though not greatly exceeding the lunar in bulk. Its roughened dorsal face is considerably higher vertically than that of the magnum, and the palmar hook is broad, massive, depressed, and decurved, but not elongate. The proximal surface is unequally divided between the facets for the lunar and unciform, the latter being considerably the wider of the two. The lunar facet is somewhat oblique in position, broader in front and narrowing behind, somewhat concave transversely and strongly convex antero-posteriorly. The facet for the cuneiform has similar curves, but narrows toward the ulnar side. On the radial side is the large, infero-lateral facet for the projection arising from mc. III, and above and behind this a surface for the extension from the ulnar side of the magnum. The distal surface displays a large and nearly plane facet for mc. IV, and a narrow, concave one for mc. V; the latter is almost as much lateral as distal, and is continued back the full depth of the palmar hook. The unciform of the European species of *Ancodus* is much the same as in the American, but is broader in proportion to its height; its ulnar border is less abruptly truncated, and is drawn out into a sharp angle. The lunar facet is also somewhat wider, the displacement of the magnum toward the radial side having hardly advanced so far. The unciform of *Oreodon* is somewhat higher in relation to its width, and the posterior hook is decidedly more compressed and slender. The lunar facet is much more distinctly divided into anterior convexity and posterior concavity, while the cuneiform facet is rounded and convex in both directions. The highest point of the bone is not, as in *Ancodus*, formed by the ridge between the two facets, but by the summit of the arched surface for the cuneiform.

I have elsewhere shown (No. 9, p. 165) that the manus of *Ancodus* is pentadactyl, with a pollex which may fairly be called well-developed, and though it can hardly have been of much functional importance, it is relatively larger than in any other artiodactyl in which the presence of the pollex has been demonstrated.

The first metacarpal is almost exactly half the length of the second, measured along the median line; it has an enlarged, rugose head bearing a narrow facet for the trapezium, which is lower and slightly concave in front, higher and somewhat convex behind. The shaft is compressed in its proximal part, but of considerable dorso-palmar depth; it tapers inferiorly, expanding again to the distal end. The distal trochlea is well-developed and of almost hemispherical form, with a carina which is confined to the palmar side. It is obvious that this metacarpal must have been provided with both phalanges. The pollex of *Oreodon*, and even of the earlier and more primitive *Protoreodon*, is considerably more reduced and slender than that of *Ancodus*, and it is surprising to find a White River genus, so advanced in many respects, retaining such an ancient character in so perfect a way.

Kowalevsky did not suspect the possibility of the existence of a pollex in *Ancodus*, or, indeed, in any artiodactyl, and hence his figures of mc. II do not show whether it had the facets for mc. I, which occur in the American species.

The second metacarpal is much larger in every dimension than the first, and has about the same relative development as in *Oreodon*. The head is narrow, and is excavated on the radial side to receive the head of mc. I, for which it has distinct facets. It is also in contact, to a slight degree, with the trapezium. The trapezoid surface is narrow and oblique, rising toward the ulnar side, concave transversely and slightly convex in the antero-posterior direction. The ulnar border of the proximal end overlaps the head of mc. III, and abuts against the magnum by a facet, which is proportionately better developed than in *Oreodon*, and extends along the entire dorso-palmar depth of the head. The shaft is flattened and compressed, but stout and considerably curved. The distal trochlea is rounded and prominent, and demarcated from the shaft on the dorsal face by a narrow depression. Except for the larger size and greater prominence of the magnum facet, this bone is almost a copy of the corresponding one in *Oreodon*. The Ronzon specimens of mc. II, figured and described by Kowalevsky, would appear to have a less prominent projecting process for the magnum and a straighter and more slender shaft.

The third metacarpal is the longest of the series, rising above mc. IV proximally, and descending below it distally, but, on the other hand, it is a little narrower transversely than that bone. The head is broad and heavy; on the radial side, below the head, the shaft is excavated to receive an expansion of mc. II. There is a relatively large surface for articulation with the distal side of the projection which mc. II sends to meet the magnum; this surface is divided into two parts by a narrow sulcus. The posterior projection from the head is longer, wider, and more massive in proportion than that of *Oreodon*, and the portion of the magnum facet which extends upon it is broader and inclined more toward the radial side; the main portion of the same facet is rather less strongly convex from before backward than in *Oreodon*. The unciform projection is large and heavy and bears a plane surface for that carpal; on its lower side is a depression for the head of mc. IV. The shaft widens transversely toward the distal end, but is throughout rather broad and antero-posteriorly compressed, and is less thickened and rounded than in *Oreodon*. The distal trochlea is broadened and compressed in the same way; the carina is low, confined to the palmar side, and hardly visible from the anterior side. In

Kowalevsky's figure (No. 3, Pl. XXXVII, fig. 20) the two median metacarpals (III and IV) are shown as being of the same length, and mc. IV is much the more slender of the two. Whether this proportion really characterizes the European specimens, or is due to the association of bones from different individuals in the same manus, cannot well be determined. Filhol's figure (No. 1, Pl. 24, fig. 116) would favor the latter conclusion.

The fourth metacarpal is somewhat wider and markedly shorter than the third. The head bears a nearly plane facet, of subtriangular shape, for the unciform, which extends somewhat farther back upon the posterior projection than in *Oreodon*, and the depression on the ulnar side for the head of mc. V is rather more deeply marked than in that genus. The lateral facets for the adjoining metacarpals are large and flat. The shaft is somewhat more compressed in the fore-and-aft direction than that of mc. III, but is otherwise like it, as is also the distal trochlea.

The fifth metacarpal is shorter than the second, and is consequently the shortest of the series, except mc. I. It is somewhat heavier in proportion, but otherwise almost exactly like the corresponding bone in *Oreodon*. The head is quite rugose and heavy, and carries a narrow, oblique, and saddle-shaped facet for the unciform. The articular surface for mc. IV on the radial side of the head is broad in front, becoming very narrow toward the palmar side. The shaft is stout and of trihedral shape, broadening regularly to the distal end. The figures of Kowalevsky and Filhol show this bone of quite a different shape in the Ronzon species; it is longer and straighter, with a less expanded and rugose head, and is less distinctly enlarged at the distal end. Filhol's figure appears to indicate the extension of the distal carina farther upon the dorsal face of the trochlea than occurs in the American species.

The *phalanges* of the pes are much better represented in the collection than those of the manus. It will suffice for the present, therefore, to note a difference which obtains between the proximal phalanges of the fore and hind feet. In the manus the first phalanx has a subcircular proximal end, with shallow concave facet for the metacarpal, notched on the palmar border for the carina. The shaft is nearly straight, its distal portion becoming wide and much compressed in the dorso-palmar direction. The distal trochlea is very low, very obscurely divided in the median line, and not reflected upon the dorsal side of the bone. The lateral processes for ligamentous attachments are inconspicuous.

V. THE HIND LIMB.

The *pelvis* is not represented in the collection at all, except by some fragments which show that the ilium was quite broad and probably like that of *Oreodon*.

Of the *femur* (Pl. XXIV, fig. 8) only the distal portion is preserved in the specimen of *A. brachyrhynchus;* it indicates a much larger and more massive bone than the humerus. The lower part of the shaft is heavy and trihedral in shape. The surface for the attachment of the plantaris muscle is large and rugose, but does not form a deep pit or depression, as is the case in the European species. The rotular trochlea is very prominent and massive and of asymmetrical shape, the inner border rising considerably higher than the outer. The condyles are large and project strongly backward, and are of unequal size, the outer one being distinctly the larger and more prominent. The strong backward projection of the condyles, and the great prominence of the trochlea in front give to this portion of the femur an unusual antero-posterior diameter. In other respects the femur resembles that of *Oreodon*, except for its much greater size.

In *A. americanus* the femur has a widely expanded and antero-posteriorly compressed proximal end. The head is rather small and set upon a short, but distinct neck, differing much in appearance from the long, slender, and prominent neck of the femur figured by Kowalevsky. The head is far removed from the great trochanter, with which it is connected by a long, compressed bridge of bone. The great trochanter is high, rising somewhat above the level of the head, very deep antero-posteriorly, massive and rugose, with recurved posterior border. The digital fossa is deep but small, having but little extent either vertically or transversely, and there is no distinct ridge connecting the great and second trochanters. The shaft is very long, slender, and rounded, not nearly so heavy as in *A. brachyrhynchus*, and is notably less massive distally. The condyles are much smaller and less prominent than in the latter species, the rotular trochlea less elevated and, consequently, the whole distal end is much less extended from before backward than in the last-named species.

The *patella* is a remarkably large and massive bone, which may be described as being like the knee-cap of *Oreodon* with the addition of a long, broad, and thick tuberosity, which covers nearly the whole anterior face. The proximal surface is abruptly truncated and slightly concave, with raised anterior border. The antero-posterior diameter is greatest along this line. In its upper three-fourths the bone is of nearly equal transverse and fore-and-aft diameters, though the anterior face is narrower than the posterior, while the distal portion narrows abruptly to form an incurved hook, which has hardly more than one-third the fore-and-aft depth of the rest. The articular surface is unequally divided by a ridge into two facets for the trochlea of the femur; transversely the two are of the same width, but the outer one has the greater height. The inner border of the internal facet is somewhat recurved, so as to slightly cover the mesial face of the femoral trochlea. The same feature occurs in *Protoceras*, but in a very much more marked degree.

The *tibia* is considerably longer than the radius, much more so, proportionately, than in *Oreodon*, but in construction it is exceedingly like the tibia of that genus, though, of course, much larger and more massive in every way. The proximal condyles are less oblique in position and less strongly convex in the antero-posterior direction; the spine is bifid and higher than in *Oreodon*, and the groove dividing it is deeper, but not so wide. The cnemial crest is very heavy and prominent, extending farther down the shaft than in *Oreodon*, and not terminating so abruptly below, but sloping gradually into the shaft, while proximally it ends in a very massive and rugose surface for the attachment of the patellar ligament. The sulcus for the tendons of the anterior tibial muscles (tibialis anticus, flexor longus digitorum) is remarkably deep, and its entrance is narrowed by a projection from the posterior side. The shaft is shaped almost exactly as in *Oreodon*, with a nearly straight posterior border, but having a considerable lateral curvature. The distal end likewise is very similar to that of the last-named genus, except that the internal malleolus is much shorter, thinner, and less pointed. The external cotyle for the astragalus is considerably wider than the internal, but its articular surface is more extensively invaded by the large sulcus, which, just as in *Oreodon*, crosses the intercondylar ridge; this ridge forms a somewhat more prominent anterior tongue than in the latter. There is a well-defined distal facet for the fibula in addition to the lateral one on the distal end of the shaft, the fibula extending considerably beneath the tibia. In *Oreodon* this also occurs, but the displacement is less, and consequently the facet in the distal face of the tibia is less developed.

Of the *fibula* only the distal end is preserved in any of the specimens, but it is plain that no coalescence between the two leg-bones occurred at any point, and that the shaft of the fibula, though slender and reduced, was, in all probability, complete and uninterrupted. The distal end is narrow and transversely compressed, but considerably expanded antero-posteriorly, much more than the depth of the calcaneal facet. This facet is somewhat saddle-shaped, concave transversely and convex from before backward; it is broadest about the middle of its course, narrowing toward the ends. A strong shelf projects inward from the mesial side of the fibula, which extends underneath the tibia and bears a facet on its proximal side which articulates with the surface already described on the distal face of that bone. The mesial side of this fibular projection bears a large facet for the astragalus. Kowalevsky's figure (Pl. XXXV, fig. 3) shows that in *Diplopus* the distal end of the fibula is much like that of *Ancodus brachyrhynchus*, but the calcaneal and astragular facets are larger and of a somewhat different shape.

The *pes* (Pl. XXIII, fig. 4; Pl. XXIV, fig. 9) is, in some species at least, much larger than the manus in every dimension, and especially in vertical height. The tarsus is, on the whole, very much like that of the oreodonts, but with some characteristic features of its own.

The *astragalus* is relatively much higher and narrower than that of *Oreodon*. The proximal trochlea is more symmetrical than in the European species of *Ancodus*, owing to the lesser height of the external condyle, and the median groove is broader. The distal trochlea is proportionately much higher than in *Oreodon*, and separated from the proximal one by a wider interval; the navicular facet is much narrower and the cuboidal wider. The calcaneal facets of the astragalus are very characteristic, and differ in a marked way from those found in the European species of *Ancodus*, as well as from those of *Oreodon*. The articular surface for the sustentaculum of the calcaneum is divisible into two facets, the outer one of which is narrow, simply convex proximo-distally and plane transversely, and presents toward the plantar side; this corresponds to the entire sustentacular surface in *Oreodon*. The internal, or mesial, sustentacular facet is of the same proximo-distal length as the outer, but extends much farther distally, where it terminates upon the plantar face of the ridge separating the cuboid and navicular surfaces of the distal trochlea, while it does not extend so far proximally by a corresponding amount. This accessory facet is inclined in position, facing obliquely toward the external and plantar sides. Of the external calcaneal facets, the proximal one is very unusually prominent and very deeply concave, describing almost a semicircle, which closely embraces the corresponding protuberance on the calcaneum. This facet is also divided by a sulcus into two parts, proximal and distal, which are separated by a considerable interval. The distal external facet for the calcaneum is large and plane. The whole mode of articulation between the calcaneum and astragalus is peculiar and implies a very uncommon freedom of movement.

So far as can be judged from Filhol's figures (No. 1, Pl. 26, figs. 132–3) these characteristics do not occur in the astragalus of *Ancodus leptorhynchus*, which is more like that of *Oreodon*, nor does Kowalevsky mention them in his description of the other species.

The *calcaneum* is correspondingly differentiated to suit the changes of the astragalus. The tuber is long, compressed, and deep, with nearly parallel dorsal and plantar borders, somewhat expanded and club-shaped at the free end, which is marked by the sulcus plantaris, so general among the artiodactyls. The distal end is not, as in *Oreodon*, suddenly contracted to form the cuboidal facet, the plantar border remaining straight throughout. The sustentaculum differs markedly from that of all the oreodonts in its much greater prominence, and in the possession of an accessory facet for the astragalus. These two facets form a continuous articular surface, but being placed at different angles, their junction forms a distinct ridge which fits into the reëntrant angle between the corresponding facets of the astragalus. The external facet of the sustentaculum is the larger of the two, is simply concave, and presents obliquely toward the distal and dorsal aspects of the bone; the inner facet is narrow, nearly plane, and presents distally and internally. It is this internal accessory facet which gives its great prominence to the sustentaculum, which in the European species does not project much more strongly than in *Oreodon*, owing to the absence of the inner facet. The fibular facet forms a high, elongate prominence, which, when seen in profile, has much the same shape and proportions as in Filhol's drawing of *A. leptorhynchus*, but it is thicker transversely than in that species, and on its internal side are two convex facets for the astragalus. Below the fibular prominence the calcaneum has a greater dorso-plantar depth than in the European species, and the cuboidal facet is less oblique with reference to the long axis of the bone, though more so than in *Oreodon*. This facet is somewhat saddle-shaped, being concave in the dorso-plantar direction and somewhat convex transversely; the plantar end of the facet is not reflected over upon the inner surface of the bone, as is the case in *Oreodon*. The distal astragalar facet is unusually large, occupying the whole antero-posterior diameter of the calcaneum, and is nearly plane. This facet is not clearly indicated in Filhol's figure. (Pl. 26, fig. 137.)

The *cuboid* is quite peculiar; on the dorsal, or anterior, side it is high but contracted, much narrower than on the plantar side. The proximal facets are of unequal size, that for the calcaneum being considerably the wider. The latter is convex antero-posteriorly and is broad behind, narrowing toward the front, descending lower upon the dorsal face than in the specimens figured by Kowalevsky (Pl. XXXVIII, fig. 1), and separated by a distinct groove from the ascending process which forms the astragalar facet. The latter surface is divided into two facets, dorsal and plantar, widely separated by a broad and deep sulcus. The plantar surface of the cuboid is very broad and, in general, agrees with the shape found in the European species, though differing in some details. Kowalevsky says of his specimens: "Looking at the cuboid from the posterior aspect, we perceive a very broad and rough transverse ridge for muscular and ligamentous attachment, running through the whole breadth of the bone. . . . This ridge does not reach the level of the distal articular surface of the cuboid, which is the lowest point of the bone" (p. 57). "Instead of the broad transverse ridge seen on the posterior surface of the cuboid in the Hyopotamus, the cuboid of the two-toed Diplopus has this ridge prolonged downward in a beak-like process quite of the same shape as in the common Hog. This posterior beak descends lower down than the distal articular surface of the cuboid, and exhibits on its inner side an elongated facet, by which this beak articulates with a corresponding cuboid facet on the outer side of the posterior prolongation of the fourth metatarsal. . . . In my specimens of Hyopotamus from Puy the posterior prolongation of mt. IV is not well preserved; but as there is no downward prolongation on the cuboid and no facet, the cuboid seems not to have articulated with this posterior prolongation of the fourth metatarsal, and it does not so articulate in Anoplotherium and Hippopotamus" (pp. 58–59).

In *A. brachyrhynchus* there is a very massive but rather short posterior beak which does articulate with the posterior prolongation of mt. IV, just as Kowalevsky describes it in *Diplopus*, but internal to this the broad transverse ridge extends beneath nearly the entire breadth of the navicular and above the posterior hook of mt. III, and has a broad contact with the entocuneiform. On the tibial side the cuboid displays two large facets for the navicular, which are separated by a continuation of the same wide and deep sulcus that divides the astragalar facet into two parts. The dorsal navicular facet presents internally, the plantar one superiorly. The distal facets for the metatarsals do not differ notably from those of the European species.

In *Oreodon* the cuboid is relatively lower and broader than in *Ancodus;* the calcaneal facet is not cut so deeply into the anterior face, and the astragalar facet is continuous, not being divided by a sulcus. The posterior beak is rudimentary and does not articulate with mt. IV, while the entocuneiform is excluded from any contact with the cuboid by the long plantar beak of the navicular, which intervenes between them. The distal facet for mt. V is relatively much smaller than in *Ancodus.*

The *navicular* is high and rather narrow, its greatest diameter being the antero-posterior, while in *Oreodon* this is exceeded by the transverse width. The plantar hook, which in the latter genus is long and well developed, is small, hardly more than a rudiment. On the fibular side the facets for the cuboid correspond in size, shape, and position to the navicular surfaces on that bone, already described. The distal side displays separate facets for the cuneiforms. That for the ectocuneiform is very large and occupies the whole dorsal half of the distal surface. There is a second isolated facet for the same bone, almost circular in shape, which stands behind the principal surface and at a somewhat higher level. The mesocuneiform facet is very narrow, and is confined to the tibial margin of the navicular, while that for the entocuneiform is considerably larger, more concave and more oblique, being continued down upon the tibial side of the rudimentary beak. This facet is almost entirely plantar in position, and concealed when the bone is seen from the front.

The *entocuneiform* is of very remarkable shape, quite unlike that of any artiodactyl with which I have been able to compare it, though most resembling that of the hippopotamus. It forms a high and very broad plate, not unlike a pisiform in appearance, and had it been found isolated, would have been very puzzling. Antero-posteriorly it is compressed and thin, but has a rugose surface. The proximal end is contracted to form the navicular facet, which is transversely convex. Laterally it articulates with the cuboid and anteriorly with the mesocuneiform, and extends down behind the second metatarsal, with which it has an unusually long contact. Distally it bears a facet for the rudimentary first metatarsal. In *Oreodon* the entocuneiform has an entirely different shape, being high and narrow, articulating more extensively with the navicular hook, but without facets for the cuboid or first metatarsal. The latter occurs in *Protoreodon* (*fide* Marsh). This element has not yet been identified for any of the European species of *Ancodus*.

The *mesocuneiform* is small and stands at a somewhat higher level than the ectocuneiform. Though the specimen here described is of a young animal, in which the epiphyses are still separate, an incipient coössification of the meso- and ectocuneiforms is very plainly marked, and in the adult the two bones are doubtless as indistinguishably ankylosed as in *Oreodon*. In the European species the ankylosis of these elements is, according to Kowalevsky, subject to individual variation; in some specimens the two have coalesced, while in others they are separate. In the specimen of *A. americanus* from the Metamynodon-beds the ecto- and mesocuneiforms remain separate. How far this difference is characteristic of the species, and how far subject to individual variation, cannot be definitely decided at present.

The *ectocuneiform* is higher, narrower, and deeper than in *Oreodon*, but as in that genus, there is a small lateral surface for the second metatarsal. The proximal side bears two facets for the navicular, a large one in front of subtriangular shape, and behind this a small circular and isolated facet.

It is somewhat difficult to determine from material at present available the relative size of the metatarsals in the different species. The skeleton upon which this description is for the most part founded has no metatarsals associated with it, and of the tarsus only the calcaneum and astragalus. In a second fragmentary skeleton the metatarsals and metacarpals are of nearly the same length, while a third specimen, a beautifully preserved hind-foot, of which the calcaneum and astragalus agree closely in size with those of the first-named specimen, the metatarsals much exceed in length the metacarpals of the latter. A more extensive series of fore- and hind-feet associated together will be required to determine accurately these relations. In the following description the isolated pes is made use of.

The *metatarsals* differ from those of *Oreodon* in the greater proportionate development of the median pair and reduction of the laterals. The first metatarsal is a small nodular rudiment of irregular shape, which is broadest proximally, tapering distally to a blunt point, and is of roughly trihedral section. It is attached to the distal end of the entocuneiform, but there is no clearly defined facet, and doubtless the joint was very imperfectly developed. No phalanges are connected with the rudimentary metatarsal, and the hallux is thus far more reduced than is the pollex, which is relatively larger than in the dogs. The rudiment is entirely plantar in position, being concealed from the front by mt. II, behind which it lies.

The second metatarsal is long, much compressed laterally, and of trihedral shape, expanded and somewhat thickened distally. The head is very narrow; it bears a small facet for the mesocuneiform, and abuts by a minute surface against the tibial side of the ectocuneiform, beneath which the shaft is excavated to receive an expansion of the head of mt. III. The postero-internal angle is cut away at the proximal end, forming a long, oblique surface, overlapped by the wide entocuneiform. The distal epiphysis has been lost from the specimen.

The third metatarsal is very long and, though much heavier in every way than the laterals, is slightly shorter and considerably narrower than mt. IV, while in *Oreodon* it is somewhat longer. The proximal end rises less above the head of mt. IV, and has a smaller contact with the cuboid than in the specimen figured by Kowalevsky (Pl. XXXVIII, fig. 1) more so than in that figured by Filhol (Pl. 25, fig. 124), and the head is relatively narrower than in either. On the fibular side, below the head, is a deep pit into which is received a corresponding projection from mt. IV. By means of this and the mode of articulation with the tarsals the median pair of metatarsals are very firmly locked together. From the plantar side of the head arises a long and stout projection, which is held in place by the cuboid proximally, the entocuneiform internally, and mt. IV externally. The shaft is more compressed antero-posteriorly, and has a more flattened dorsal face than in *Oreodon*. The distal trochlea is wider proportionately than in that genus, but is demarcated from the shaft in the same way by a deep pit on the dorsal face of the bone. In all the metatarsals the carina is entirely plantar.

The fourth metatarsal is the longest and heaviest bone of the series; it does not much exceed mt. III in length, but is everywhere distinctly broader, except at the proximal end. Both Kowalevsky's and Filhol's figures show, however, that in the European species it is rather more slender than mt. III. Its tarsal connections are exclusively with the cuboid, but are nevertheless quite complicated. On the dorsal side the articulation is of the usual type, but the long and massive plantar projection is firmly wedged in between the corresponding projection of mt. III, and the cuboid both proximally and externally, making a joint of great strength. Something of the same kind may be observed in *Oreodon*, though much less completely elaborated, while the European species of *Ancodus* would appear to be intermediate in this respect between *Oreodon* and *A. brachyrhynchus*, the internal projection from the plantar half of the cuboid being much stronger in them than in *Oreodon.*

The fifth metatarsal is somewhat longer than the second and of quitc a different shape. The shaft is more compressed and less trihedral in section, and though very narrow, has considerable dorso-plantar diameter. The head has a long projection from the posterior side, which extends beneath and appears to articulate with the plantar hook of the cuboid. In *Oreodon* this projection is rudimentary and does not touch the cuboid. The shaft is more compressed and less rounded than in the last-named genus, and less expanded distally; the trochlea is very similar in both genera.

The *phalanges* of the pes are very different from those figured by Kowalevsky and Filhol, and, so far as the median digits are concerned, are much more like those attributed to *Diplopus.* It is, however, uncertain whether the material accessible to those writers enabled them to discriminate between the phalanges of the manus and those of the pes. In the specimen here described there is fortunately no room for doubt on this subject, all the bones of the hind-foot being preserved in their natural position and connections by the matrix.

The first phalanx of the second digit is very much longer, more slender and compressed than that figured by Kowalevsky and Filhol, and has considerable resemblance to the proximal phalanx of one of the median digits in the deer or antelope. The proximal end is compressed, but tbick (antero-posteriorly) with a shallow, concave facet for the metatarsal, which is grooved only on the plantar margin. The shaft is much contracted in both directions, and the distal expansion is but moderate. The distal trochlea is deeper than wide, is somewhat notched in the median line, but not at all reflected over upon the dorsal side of the bone.

The second phalanx is hardly more than half the length of the first, but is relatively much stouter. The proximal trochlea is divided by a low median ridge into two shallow concavities, which are wider than the corresponding surfaces on the distal end of the first phalanx. The shaft is short and stout and somewhat unsymmetrical, being depressed and hollowed on the fibular side. The distal trochlea has a relatively larger dorso-plantar diameter than that of the first phalanx, and reflected more upon the dorsal side; it also is slightly asymmetrical.

The ungual phalanx is very like a median ungual of *Oreodon,* both in size and shape, but is more depressed, with a more regularly arched dorsal surfacc, and blunter distal end. The proximal articular surface is obscurely divided into two facets, of which that on the fibular side is smaller and more oblique in position with reference to the long axis of the bone.

The phalanges of the fifth digit are essentially like those of the second, the only noteworthy difference being that the second phalanx is distinctly narrower and more slender. In spite of their very elongate proximal phalanges, the lateral digits cannot have reached the ground, and must have formed mere dew-claws, the unguals extending only to the lower end of the proximal phalanges of the median digits. This shortening affects principally the metatarsals.

Filhol's drawing of the phalanges of the lateral digits of *A. velaunus* (Pl. 25, fig. 124) shows them to have been different from those here described. The proximal one is much shorter and heavier, the second more slender, and the ungual much smaller and more pointed. The relative lengths of the median and lateral digits are about the same in both species, but in *A. velaunus* the lateral metatarsals are much longer and the phalanges shorter, while in the American form these proportions are reversed.

In the median digits the proximal phalanx does not exceed those of the lateral digits in length, but is very much larger in every other dimension, and especially in breadth. The general shape is not unlike that found in *Oreodon*, but the bone is straighter, broader, less arched, less compressed antero-posteriorly, and the distal trochlea is less deeply notched in the median line. The phalanx is broadest and deepest at the proximal end, and the articular surface is a shallow concavity, notched on the plantar border for the keel of the metatarsal. The lateral processes for ligamentous attachments just above the distal trochlea are better marked and more prominent than in *Oreodon*, and the pits are correspondingly deeper.

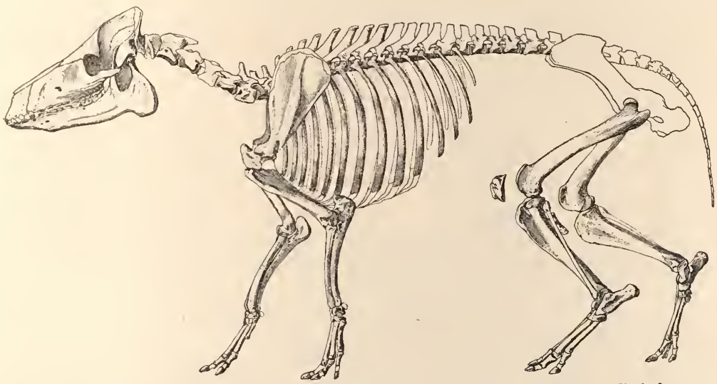
The second phalanx is asymmetrical, though those of the two median digits form together a nearly symmetrical pair; not entirely so, however, for the two are not quite alike. This phalanx is shaped like the corresponding one of the lateral digits, but is much larger and heavier. The proximal trochlea is very obscurely divided into two facets, and the distal trochlea is oblique, inclining toward the median line, as it passes dorsally; it is reflected distinctly farther upon the dorsal side of the bone in the fourth digit than in the third.

The ungual phalanx is much like that found in *Oreodon*, but is relatively broader, more regularly arched on the dorsal surface, more depressed, of less dorso-plantar diameter, and more bluntly rounded distal end. In spite of these differences, the unguals of the two genera are manifestly of the same type, a fact which is not without morphological significance, because this type is not at all a common one.

The phalanges of the median digits in the European species, according to Kowalevsky and Filhol, are in many respects quite different from those here described and referred to *A. brachyrhynchus*. The proximal one is more slender and tapering, as well as longer in proportion to the metatarsals. The second is much less massive, and the ungual very much narrower, more compressed, and pointed. In fact, the unguals of *A. brachyrhynchus* are more like those of *Diplopus* than those of *A. velaunus*.

VI. RESTORATION OF ANCODUS.

The general appearance of the skeleton of *A. brachyrhynchus* is not unlike that of *Sus scrofa*, though with manifold differences of detail. The head is rather shorter in proportion and of quite a different shape, the backward shifting of the orbits in *Sus* and the elevation of the posterior part of the skull, giving to that animal special peculiarities. Then, too, the absence of the great tusk-like canines in *Ancodus* completely changes its physiognomy. The neck is longer and more curved, but more slenderly and lightly built, with shorter and less massive spines and processes on the vertebræ. So far as can be judged from the available material, the trunk is relatively shorter, and the spines of the thoracic vertebræ not



ANCODUS BRACHYRHYNCHUS? Restoration 1-10 natural size. Skull, neck, thorax, fore-limb, femur and tibia from one individual (No. 10,650).

nearly so high or heavy. The ribs are longer, more slender and more curved, and the thorax more capacious. The bones of the fore-limb are somewhat longer in proportion, and of decidedly less massive construction, with the ridges and prominences for muscular attachment less developed. The bones of the hind-limb show few noteworthy differences. While there is considerable general likeness between the skeletons of *Ancodus* and *Sus*, it must be remembered that there is nothing in this likeness to suggest a near relationship between the two genera, all the significant morphological details of structure in teeth, skull, and skeleton representing entirely distinct lines of differentiation.

Between *Ancodus* and *Oreodon* the resemblances are closer and much more indicative of relationship. When the two skeletons are compared, the most striking differences are found in the skull, and especially in the facial region. In *Oreodon* the face is extremely short and rather high vertically, descending little forward, and the chin is abruptly rounded and steeply inclined, while in *Ancodus*, on the other hand, the muzzle is greatly elongated and very low, especially toward the front; the chin is pointed and very procumbent. Another difference between the two genera consists in the fact that in *Ancodus* the disproportion between the length and weight of the fore- and hind-limbs is greater. The neck is also somewhat more elongated in the latter, though not very much so. In nearly all other points the resemblance between the skeletons of the two genera is very close even in minor details.

The proportions of *A. americanus* are quite different from those of *A. brachyrhynchus*. The neck is shorter and lighter, the trunk of almost the same length, while the limbs are longer and lighter in proportion to their length.

So far as can be judged from Kowalevsky's restoration of *Anthracotherium* (No. 4, Pl. XV) the skeleton of that genus differs from that of *Ancodus* principally in the much greater elongation of the trunk and the shortness of the limbs.

VII. THE RELATIONSHIPS OF ANCODUS.

Ancodus is usually, and no doubt correctly, classed as a member of the *Anthracotheriidæ*, but our survey of its osteology has brought out numerous and suggestive resemblances to the oreodonts. Both groups display many divergent specializations, but at the same time there is a fundamental similarity apparent in all parts of the structure, which renders the reference of these likenesses to mere parallelism an improbable one. The cranium is closely similar in the two groups in almost every detail of construction, except the shape of the occiput, which in *Oreodon* is higher and narrower and with the superior wing-like processes of the supra-occipital much better developed. *Agriochœrus* agrees more closely with *Ancodus* in the character of the occiput than *Oreodon* does with either. The orbit, which in the latter genus is completely encircled with bone, remains open behind in *Ancodus*, as is also the case in *Agriochœrus* and *Protoreodon*. The three genera further agree in the absence of the lachrymal depression in front of the orbit, which is so characteristic a feature of *Oreodon*. In the proportionate development of the facial region *Oreodon* and *Ancodus* have diverged widely. In the former the face is shortened, the lower teeth forming an uninterrupted series, and the upper with a diastema behind the canine only sufficient to receive the caniniform lower premolar; the premaxillaries project very little in advance of the canines, and the incisors form a nearly transverse row, the median one being but slightly further forward than the lateral. In *Ancodus*, on the other hand, the face is very greatly elongated, and forms an extremely long, slender, depressed and tapering muzzle, to which the skull owes its characteristic physiognomy. The premaxillaries project far in front of the canines, and the incisors stand in nearly the same fore-and-aft line, which brings the median one much farther forward than the lateral, and adds materially to the length of the muzzle. This elongation of the face, however, varies as to amount in the different species and attains its maximum in *A. leptorhynchus*, while in the American species it is generally less than in the European. The longest-faced of the White River forms is *A. americanus*, in which the relative length of the muzzle is nearly the same as in *A. velaunus*, the shortest of the European species. The facial elongation is increased by a shifting of the orbits. In *Protoreodon*, *Oreodon* and *Agriochœrus* the anterior rim of the orbit is above the interval between $\underline{m1}$ and $\underline{m2}$, while in *Ancodus*, as also in *Merycochœrus*, it has retreated so as to be above $\underline{m3}$. As regards the length of the face, *Agriochœrus* is intermediate between *Oreodon* and *Ancodus*, and it seems altogether probable that in this respect it has been conservative, and represents very nearly the common starting point whence the three lines diverged. As would naturally be expected, *Protoreodon* is decidedly nearer to this type than is *Oreodon*, and it is a suggestive fact that the anthracotherioids from the Titanotherium-beds, as yet but little known, have the facial proportions, length of diastemata, etc., very much as in *Agriochœrus*.

The mandible displays corresponding differences in the three diverging lines. The condyle and angle are much alike in all, but *Ancodus* is peculiar for the remarkable production of the angle below the level of the horizontal ramus, while the angle is more thickened and the condyle more elevated in *Oreodon*. The development of the coronoid process varies much within the limits of the separate families; in the American species of *Ancodus* it is high and recurved, with deep sigmoid notch, while in the European species it is rather feebly differentiated, low and of triangular shape. In *Oreodon* it is intermediate between these two extremes, and in *Protoreodon* and *Agriochœrus* it resembles the shape found in the American species of *Ancodus*. Doubtless in this respect also *Agriochœrus* and *Protoreodon* represent nearly the original condition. In all of these genera the masseteric fossa is rather small, and situated high up on the ascending ramus, and is in most of the species quite deeply impressed, least so in the European representatives of *Ancodus*. The development of the horizontal ramus varies in accordance with the elongation of the face; in *Oreodon* it is short and deep, with abruptly truncated chin and steeply inclined symphysis; in *Ancodus* it is very long and quite shallow (though in this latter respect there is much difference to be noted between the various species). *Agriochœrus* is intermediate between the two and agrees in this respect with the supposed *Anthracotherium* of the Titanotherium-beds, as well as with *Protoreodon*.

The three lines display very striking divergences in the character of the dentition, and as in the case of the skull-structure, *Agriochœrus*, in some degree, combines the features of the other two. The teeth of *Protoreodon* also have an intermediate character between the extremes of the three lines, but in a somewhat different sense. In *Oreodon* the incisors are very small and set closely together, the upper canine is trihedral and the lower one has assumed the form and functions of an incisor, its place being taken by the caniniform first premolar. The premolars have a simple form externally, but are rendered quite complex by the addition of ridges and tubercles on the inner side; none are, however, so advanced as to assume a molariform pattern. The molars are composed of four crescents and are surprisingly like those of the existing brachyodont ruminants.

In *Ancodus* the incisors are spaced well apart, and have large, spatulate crowns; the canines are ordinarily small, except in *A. leptorhynchus*, and the lower one differs but little from the incisors in shape. The premolars are much simpler than those of *Oreodon*, not having the ridges and tubercles developed on the internal faces. The upper molars are very different from those of the last-named genus; not only have they retained the protoconule, but they have very broad, low crowns, with deeply concave outer crescents, which project far toward the median part of the tooth, and with very prominent and tuberous external buttresses or styles. On the lower molars the crescents are very much higher, somewhat thicker, more conical and less completely crescentic in shape.

Agriochœrus combines some of the features of the other two genera with characteristic peculiarities of its own. It agrees with *Oreodon* in the character of the canines and caniniform first lower premolar, and in having lost the protoconule, thus making the upper molars tetraselenodont. Aside from this, however, the molar pattern is very much more like that of *Ancodus*, though the cusps of the lower ones are less elevated. The premolars are, for the most part, less complicated than in *Oreodon*. Peculiar features are the more or less complete reduction of the upper incisors, and the molariform pattern of the last premolar in each jaw.

Protoreodon nearly represents the common term from which all three types of dentition may easily have been derived, and though it has already assumed too many oreodont features to be actually the real starting point from which the later genera diverged, it greatly reduces the gaps between them. The incisors and canines are like those of *Oreodon*, the premolars have the simple compressed conical form which recurs in *Ancodus* and *Agriochœrus;* the upper molars still retain a well-marked protoconule, like that of *Ancodus*, and the lower molars are almost exactly like those of *Agriochœrus.* The particular interest attaching to *Protoreodon* consists in the proof which it gives that the oreodonts were derived from ancestors with quinque-tuberculate superior molars, having the fifth lobe in the anterior half of the crown, and this brings them into relationship with the anoplotherioids, anthracotherioids, etc., as distinguished from the dichobunids and cænotherioids, to which it seems probable that, as Schlosser has suggested, the existing lines of ruminants should be traced back.

The character of the vertebral column is very similar in both *Ancodus* and *Oreodon*, especially if the species of the former which occur in the Protoceras-beds be used in the comparison, the differences being merely such matters of detail as are incidental to the great difference of stature. In the later species of *Ancodus* (e. g. *A. brachyrhynchus*) the odontoid process of the axis is, like that of *Oreodon* and *Agriochœrus*, neither conical nor spout-shaped, but half-way between the two patterns. *Ancodus americanus* from a lower horizon, however, has a fully conical odontoid, and this shows that the resemblance of *A. brachyrhynchus* to *Oreodon* in this respect is a case of parallelism, and has been acquired within the limits of the genus.

The scapula, which as yet is very imperfectly known in *Agriochœrus*, is alike in the other two genera, both having the spine placed in the middle of the blade, dividing it into subequal fossæ. In some species of *Ancodus* the blade is broader in proportion to its height than in *Oreodon*, while in others the resemblance in outline is exact, and in all the similarity is much greater to the latter genus than to *Anoplotherium*. The character and position of the acromion are also alike in the two genera.

The humerus is much alike in *Ancodus* and *Oreodon*. In the former the intercondylar ridge of the distal trochlea is narrow and compressed, while in the former it is broad and hemispherical, and in both the internal epicondyle is very conspicuous. In *Agriochœrus* the distal portion of the humerus has its oreodont peculiarities so exaggerated as to closely approximate the creodont structure; this is to be seen in the breadth and lowness of the trochlea, perforation of the supratrochlear fossa, and the great prominence of the inner epicondyle. In this way the resemblance to the humerus of *Mesonyx* is made remarkably close; indeed the humerus of the latter is more ungulate in appearance than is that of *Agriochœrus*.

The radius and ulna are much alike in all three lines; the former has a slender, subcylindrical shaft, which is most widened and flattened in *Ancodus*, while the distal end in *Agriochœrus* has become very creodont-like. The ulna is very little, or not at all reduced, and has a very large olecranon, which in *Oreodon* is very high, and in *Ancodus* quite low.

The carpus, again, displays in each of the three lines certain specializations peculiar to each, but with a general similarity throughout; in *Agriochœrus* we find the widest departure from the common plan. In the oreodonts there is a strong tendency in the magnum to shift altogether beneath the scaphoid and to retain only a lateral contact with the lunar. This tendency, which is plainly incipient in *Protoreodon*, reaches its maximum in *Merycochœrus* and *Merychyus*. A similar tendency, though very much less marked, is observable in *Ancodus*, while in *Agriochœrus* the displacement is in the opposite sense, the magnum shifting toward the ulnar side of the hand. The individual carpal elements are quite alike in *Ancodus* and *Oreodon*, and in all three genera the trapezium is present and of some functional importance.

The manus is pentadactyl in all three lines, except in some of the later and larger specimens of *Agriochœrus*, which seem to have lost the pollex. The first digit is relatively best developed in *Ancodus*. In all three the connections of the metacarpus with the carpus are of the unreduced type, the third metacarpal being excluded from the trapezoid by the contact of the second with the magnum. In *Oreodon* and *Ancodus* the phalanges are similar; the unguals are very characteristic and of a type not common among the artiodactyls. The European species of *Ancodus* seem to have modified this type of ungual, giving a smaller and more pointed hoof than in the American forms. *Agriochœrus* departs from all known artiodactyls, recent or extinct, in the character of its phalanges. The unguals are large, compressed, and claw-like, and the articulations of the other phalanges resemble those of the *Ancylopoda* rather more than those of the ungulates.

The hind-leg of *Ancodus* is in all essentials like that of *Oreodon*. The proximal end of the femur is more expanded transversely, and the shaft is relatively longer. The patella is more massive; the internal malleolus of the tibia is less extended, while the distal end of the fibula has moved somewhat more completely beneath the tibia. The shaft of the fibula is of about the same relative proportions in both genera. In *Agriochœrus* the knee-joint has acquired a curious resemblance to that of the carnivores, doubtless in correlation with the extraordinary character of the hind-foot.

The tarsus of *Ancodus* is much more specialized than is the carpus; all its elements are notably higher than in *Oreodon* (though this is subject to considerable specific variation), and, therefore, much more so than in *Agriochœrus*. The special characters of the tarsus, however, resolve themselves principally into the remarkably complex and perfect articulations between the calcaneum and astragalus. These peculiarities are much more strongly marked in the American forms of *Ancodus* than in the European, and even among the former some species have these articulations more perfectly differentiated than others. Another notable feature is the great size and peculiar shape of the entocuneiform. There is a tendency, though a variable one in both the European and American species, for the meso- and ectocuneiforms to ankylose, as in *Oreodon*. The tarsus of *Agriochœrus* does not differ in any noteworthy way from that of *Oreodon*, except in the greater relative breadth and height of its various elements.

The metatarsus is more or less peculiar in each of the three genera. In *Agriochœrus* the pes is almost isodactyl, the median metatarsals not much exceeding the laterals in length. In *Ancodus* the hallux is reduced to a nodular rudiment of the metatarsal without phalanges, and the lateral metatarsals are so much shorter than the median pair that the second and fifth digits cannot have reached the ground. In *Oreodon* the hallux has entirely disappeared, but, on the other hand, the median digits do not exceed the lateral pair so much as in *Ancodus*. Here, again, *Protoreodon* serves to connect the two White River genera. In a recent paper (No. 7, p. 267) Marsh has pointed out that *Protoreodon* (*Eomeryx*) possesses a nodular rudiment of the first metatarsal. The tarso-metatarsal articulations are nearly the same in all four genera, except that the second metatarsal, which in *Protoreodon*, *Oreodon* and *Ancodus* has a small lateral contact with the mesocuneiform, is in *Agriochœrus* excluded from that element.

From this rapid comparative survey of the osteology of *Ancodus* and *Oreodon* the numerous important resemblances between them become at once obvious, though the correspondences are accompanied and, to some extent, concealed by many differences. The similarities between *Ancodus* and the oreodonts are so numerous and so general that any reference of them to parallelism seems altogether unlikely. In the skull, teeth, vertebræ, limbs and feet, the resemblances are fundamental and point to community of descent. This result may, perhaps, seem unlikely in view of the exclusively American distribution of the oreodonts throughout their history, and of the probable European origin of *Ancodus*, but it must be remembered that a common ancestor of the Bridger age is all that such a view postulates. I have elsewhere suggested that the Bridger representative of the oreodonts may be the very imperfectly known genus *Helohyus*. The same formation has yielded teeth of a similar type, but considerably larger, which may well represent the ancestor of *Ancodus*. That the genus has not yet been reported from Europe is not surprising in view of the very scanty Eocene fauna as yet known in that region. The indications, at present known, all go to show that *Ancodus*, *Oreodon*, and *Agriochœrus* represent three divergent branches of the same artiodactyl stem, the starting point of which will prove to be some middle Eocene genus with pentadactyl feet and teeth of the type of *Helohyus*. Probably the agriochœrid and oreodont lines diverged from each other somewhat later than *Ancodus* did from both, though, in view of the extraordinary specializations which *Agriochœrus* exhibits, this view is uncertain, and a decision upon it must await the event of future discoveries.

The possibility of an American origin of *Ancodus* must not be overlooked. No one can imagine that we have yet obtained more than an insignificant fragment of the Uinta fauna, and the number and variety of Bridger artiodactyls are far greater than the described genera would lead one to expect; this is indicated by numerous remains which, unfortunately, are too fragmentary for satisfactory identification. While the facts at present known all seem to point to the origin of *Ancodus* in the Old World and its migration to America, in the interval between the Eocene and the Oligocene (Uinta and White River), yet until the American artiodactyls from the middle and upper Eocene are far better known than at present, such a conclusion cannot be regarded as final.

	Ancodus brachyrhynchus?	Ancodus americanus?	Ancodus sp.
Upper premolar-molar series, length	0.125		
" premolar series, length	.062		
" molar series, length	.063		
Lower molar-premolar series, length	.145		
" molar series, length	.078		
" premolar series, length	.067		
Skull, length from occipital condyles	.338		
" height from inion to angle of mandible	.203		
Cranium, length from for. mag. to front margin of orbit	.153		
Face, length from orbit to incisive alveolus	.182		
Sagittal crest, length	.083		
Premaxillary, "	.044		
Mandible, "	.302		
" height at condyle	.128		
" " coronoid process	.154		
" depth at m3	.049		
" " p3	.043		
" breadth of angle, obliquely from $\overline{m3}$	.119		
Atlas, width	.126		
Axis, length of centrum	.058	.040	
Scapula, height	.225		
" greatest width	.113		
Humerus, length (fr. ext tuberosity)	.234		
" width of distal trochlea	.033	.035	
Radius, length	.192		
" width of distal end	.036		
Ulna, length	.231		
" height of olecranon	.042		
Metacarpal I, length	.042		
" II, "	.078		
" III, "	.096		
" IV, "	.088		
" V, "	.065		
Metacarpal I, breadth of proximal end	.009		
" II, " " "	.013		
" III, " " "			
" IV, " " "	.017		
" V, " " "	.010		
Femur, length (from great trochanter)		.298	
" breadth of proximal end		.087	
" thickness of distal end (fore-and-aft)	.085	.071	
Tibia, length	.247		
" width of proximal end	.060		
" " distal "	.040		
Calcaneum, length	.097	.105	
Astragalus, length	.047	.055	.052
" width of proximal trochlea	.028	.027	.027
" " distal "	.030	.029	.029
Metatarsal I, length			.017
" II, "			.093
" III, "		.123	.113
" IV, "			.117
" V, "			.088
Metatarsal I, width of proximal end			.011
" II, " " "			.009
" III, " " "			.017
" IV, " " "		.018	.016
" V, " " "			.006
First phalanx, II digit, length			.035
" " III " "		.037	.040
" " IV " "			.039
" " V " "			.034
Second phalanx, II digit, length			.016
" " III " "			.022
" " IV " "			.022
" " V " "			.017
Ungual phalanx, II digit, length			.018
" " III " "			.026
" " IV " "			.028
" " V " "			.018

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EXPLANATION OF THE PLATES.

PLATE XXIII.

FIG. 1. *Ancodus brachyrhynchus?*—Skull, from the right side, ½ natural size.

FIG. 2. *Ancodus americanus?*—Base of skull, ½ natural size.

FIG. 3. " " Occiput, ½ natural size.

FIG. 4. *Ancodus* sp.—Plantar view of part of pes, showing rudimentary mt. I, ⅔ natural size.

PLATE XXIV.

FIG. 5. *Ancodus brachyrhynchus?*—Right humerus, front view, ⅔ natural size.

FIG. 6. " " Left ulna and radius, from outer side, ⅔ natural size.

FIG. 7. " " Left manus, anterior view, ⅔ natural size.

FIG. 8. " " Right femur, distal end, ⅔ natural size.

FIG. 9. *Ancodus* sp.—Right pes, anterior view, ⅔ natural size.

THE OSTEOLOGY OF HYÆNODON.

By W. B. Scott.

(Investigation aided by a grant from the Elizabeth Thompson Fund of the A. A. A. S.)

In a paper published in the Journal of the Academy of Natural Sciences of Philadelphia in 1887 (No. 6) I gave an account of the osteology of this genus so far as the materials then available would permit, but those materials were very imperfect and left much room for conjecture. The Princeton Expedition of 1894 was especially fortunate in collecting specimens of *Hyænodon,* Mr. Hatcher having found several more or less complete skeletons representing a number of different species. I am now in a position, therefore, to supplement the earlier account and to give a restoration of the skeleton of this very curious and remarkable animal.

For the sake of completeness a description of the parts of the skeleton already known is added to those which are here described for the first time. The rapid increase in our knowledge of the creodonts which has taken place in the last seven years makes it necessary to go over this ground again from a somewhat different point of view, in order to make clear the systematic relationships of the genus.

No less than six species of *Hyænodon* have been identified in the White River or Oligocene beds. These may be conveniently arranged as below. This tabular arrangement, however, is not intended to express the mutual relations of the species.

I. Upper premolars three, — *H. paucidens* O. & W.
II. Upper premolars four.
- A. Palatines in contact throughout; pterygoid plates of alisphenoids meeting below, — *H. leptocephalus* Scott
- B. Posterior nares between palatines, pterygoid plates separate.
  - a. Postorbital constriction in advance of fronto-parietal suture, — *H. crucians* Leidy
  - b. Postorbital constriction at or behind fronto-parietal suture.
    1. Size very large; frontal sinuses much inflated, p^2 with posterior cusp, — *H. horridus* Leidy
    2. Size moderate; sinuses less inflated, p^2 without talon, — *H. cruentus*
    3. Size minimal, $\underline{p\text{-}m}$ = 58 mm., — *H. mustelinus* sp. nov.

Hyænodon mustelinus sp. nov.

This species is characterized by its small size, less than that of any other yet known, the uniform size of the upper premolars (except $\underline{p^1}$), the acuteness of the tritocone on p^2 and p^3, the slenderness of the canines and the shallowness of the face. The type specimen consists of the facial portion of the skull and many fragments of the skeleton, including a nearly complete hind-foot. It was found by Mr. Hatcher in the lower Protoceras-beds (upper part of the White River horizon).

In the following descriptions, account will be taken of the peculiarities of each species so far as these are known. The specific differences refer principally to variations of size; in important structures there is great constancy.

I. THE DENTITION.

The structure of the teeth has long been accurately known and needs no detailed account. The incisors and canines are entirely of the carnivorous type, the external upper incisor much enlarged, and the second lower crowded back out of line with the other two. The upper premolars are very simple, essentially compressed cones, with more or fewer additional cusps. In *H. cruentus* p^2 has no posterior cusp, which is present in the other species. In the former, and in *H. horridus*, this tooth has an exceptionally high crown. On p^3 the tritocone is always present. The fourth premolar has all the elements of the carnivorous sectorial; but the deuterocone, though supported on a large fang, is itself but little developed, and the tritocone is too small to form an efficient shearing blade. In the smaller species. *H. crucians*, *H. paucidens*, and *H. mustelinus*, there is a small antero-external basal cusp. *H. paucidens* is altogether exceptional in lacking p^1 and in having p^3 placed very obliquely to the line of the jaw. The upper molars are highly characteristic. The protocone is lost, though its fang is retained. The para- and metacones are very closely approximated, and on m^2 are indistinguishably fused together; a long and trenchant posterior ridge forms a very efficient shearing blade, especially on m^2, which is much the larger of the two.

The lower premolars are likewise of very simple construction. The first has always a very low crown, but is much elongated from before backward. In *H. cruentus* p_2 and p_3 have no talon (metaconid), which is present on p_4; in *H. paucidens* the talon is present on p_3 as well as p_4, and in *H. crucians* and *H. horridus* it is present on all the premolars except the first. In *H. paucidens* p_1 is smaller than in the other species, and p_3 has the same oblique position as in the upper jaw. The first molar is one of the smallest teeth in the lower series; its crown consists of three cusps in the same antero-posterior line, a high protoconid and lower para- and hypoconid, the metaconid having disappeared. The second molar is composed of the same elements, but the enlarged and compressed proto- and paraconids form an effective trenchant blade, while m_3 is still larger, more efficient and more simplified, having lost the talon, which, however, is sometimes retained in a rudimentary condition. The characteristic feature of the dentition, both upper and lower, is the suppression of the internal cusps, p^4 alone retaining one, and the trenchant form of all the cheek teeth.

The *Milk Dentition.* The canines, and in all probability the incisors also, have representatives in the temporary dentition. As Wortman has suggested, the first premolar in both jaws appears not to be changed. The temporary second upper premolar is a very simple tooth of compressed conical shape, much elongated from before backward at the base, and with a cingulum on the inner side. While dp^2 is very much like its permanent successor, $\underline{dp^3}$ is unlike any of the permanent series; it consists of four cusps in the same fore-and-aft line, an anterior and two posterior basal cusps, with the protocone, and considerably resembles a premolar of *Temnocyon.* The last milk-tooth, $\underline{dp^4}$ is constructed like $\underline{m^1}$, but the two antero-external cusps, corresponding in position to the para- and metacones of the molar, are of more nearly equal size and less closely approximated, the posterior trenchant ridge is less elongated, and the whole crown is lower. There is no trace of an internal cusp (deuterocone), though the tooth is carried on three fangs.

The lower milk dentition has been described by Wortman (No. 4, p. 226), and I can add little to his account. The first premolar appears to have no predecessor, while $\overline{dp2}$ I have not seen, as it is replaced at such an early stage by $\overline{p2}$. The crown of $\overline{dp3}$ has a very high and acute protoconid, with a long, posterior basal expansion, upon which a small cusp appears. The last milk tooth, $\overline{dp4}$, has elements corresponding to those of $\overline{m1}$, but somewhat differently developed and not forming a shearing blade; the protoconid is high and conical, while the anterior and posterior basal cusps (para- and metaconids) are much lower and of more nearly equal size. In the specimen described by Wortman, which apparently is referable to *H. mustelinus*, $\overline{dp4}$ resembles $\overline{m1}$ much more closely than in the one which forms the basis of the foregoing description, a skull of a small species which is of uncertain reference. In this specimen the upper jaw contains, besides the canines and incisors, the following teeth: $\underline{p^1}$, $\underline{dp^{2,3,4}}$, and $\underline{m^1}$; in the lower jaw are $\overline{p1,2}$, $\overline{dp3,4}$, $\overline{m1,2}$. Another mandible, belonging to *H. cruentus* has the same teeth in use. It is evident, however, that $\overline{m1}$ has been in use much longer than $\overline{m2}$, and that at an early stage the sectorial teeth are $\underline{dp^4}$ and $\overline{m1}$, which imitates the arrangement found in the permanent dentition of the carnivora, though not in the temporary set, in which the last milk premolars operate as sectorials.

The permanent canines would appear to be erupted after all the premolars and molars are in place. At least this is true of one large specimen of a skull belonging to *H. cruentus.*

I have not been able to detect the change in the incisors of either jaw.

The only other creodont families whose dentition is at all similar to that of the *Hyænodontidæ* are the *Oxyænidæ* and the *Proviverridæ.* In the former, the premolars of the upper jaw have developed an internal cusp, which is especially strong on $\underline{p^4}$; $\underline{m^1}$ is strikingly like that of *Hyænodon* with the addition of a large protocone; $\underline{m^2}$ is a mere transverse ridge, while $\underline{m^3}$ has disappeared. The lower molars retain the metaconid and large basin-shaped heel (on $\overline{m1}$ and $\overline{m2}$ in *Oxyæna*, on $\overline{m1}$ only in *Patriofelis*), while $\underline{m^3}$ is suppressed. The *Proviverridæ* have a type of dentition which may be regarded as the starting point for both of the other families. The premolars are very simple and only p4 has an inner cusp. The upper molars are undiminished in number, of tritubercular pattern, the para- and metacones closely approximate, and a beginning of the posterior cutting ridge may be observed. The lower molars, likewise three in number, are of the tuberculo-sectorial type, and in *Sinopa*, as in *Hyænodon*, $\overline{\text{m1}}$ is much the smallest of the series.

MEASUREMENTS.

	H. HORRIDUS, No. 1.[1]	H. HORRIDUS, No. 2.	H. CRUENTUS, No. 1.	H. CRUCIANS.	H. PAUCIDENS.	H. MUSTELINUS.
	M.					
Upper molar-premolar series, length	0.127	0.137	0.106	0.072	0.062	0.058
" premolar series, length	.081	.092	.068	.046	.035	.037
" molar series, length	.046	.045	.038	.026	.026	.021
Diastema behind upper canine	.005		.005	.002	.008	.002
Upper premolar 1, length	.014		.011	.009		.006
" " 2, "	.019	.015	.017	.011	.0125	.009
" " 3, "	.022	.020	.018	.011	.013	.011
" " 4, "	.019	.020	.020	.012	.011	.009
" molar 1, "	.016	.015	.017	.012	.011	.010
" " 2, "	.031	.030	.023	.014	.0135	.011
Lower molar-premolar series, length			.118	.082	.077	.066
" premolar series, length			.060	.047	.044	.036
" molar " "	.062		.058	.035	.035	.030
" premolar 1, length			.011	.008	.009	.005
" " 2, "	.017		.015	.010	.011	.006
" " 3, "	.020		.016	.011	.0125	.007
" " 4, "	.019		.017	.012	.0115	.010
" molar 1, length	.014			.008	.009	
" " 2, "	.020			.010	.011	.009
" " 3, "	.030			.015	.0145	.011

[1] Specimen figured by Leidy.

II. THE SKULL.

The skull is in many ways peculiar, with considerable variation among the species, and certain almost constant differences between the American and European forms of the genus. Schlosser (No. 5, p. 175) points out that among the latter, two types may be distinguished. In one the mandible is elongate, with shallow horizontal ramus, its lower margin is curved throughout its length, and the symphyseal region rises very gently. In the other type the horizontal ramus is deep and massive, with almost straight inferior border, and steeply inclined symphysis. In the latter the teeth are closely crowded together, $\overline{\text{p1}}$ has usually a single fang, and $\overline{\text{p2}}$ is placed obliquely to the long axis of the jaw, while in the former the two anterior premolars are elongated and isolated. All the known American species are of the long and slender-jawed type, but *H. paucidens* distinctly approximates the short-faced group, and the general aspect of its dentition is very suggestive of that of the European *H. brachyrhynchus;* the obliquely placed tooth, however, is the third premolar instead of the second.

The skull of *Hyænodon* is thoroughly creodont in character, as may be seen in the long, narrow, and incapacious cranium, the short distance between the occipital condyles and the postglenoid process, the high sagittal crest, the deep postorbital constriction, and the relatively short preorbital region of the face. The upper profile of the skull lies in almost the same plane from the nose to the occiput, but this appearance is largely due to the sagittal crest, which becomes very high at its junction with the lambdoidal crest, the roof of the cranial cavity inclining steeply downward and backward from the postorbital constriction, and reaching a very low level at the occiput.

The *basioccipital* is short, but very broad and thin, concave on the dorsal surface and slightly concave on the ventral, which has a short, feebly marked keel in the median line. The other occipital elements early coalesce into a single mass, so that even in young specimens it is by no means easy to determine their limits. As a whole, the occiput is usually very high (it is lower in *H. paucidens*) and of subtriangular shape, with broad base and lanceolate apex. The width of the basal portion is largely due to the transverse expansion of the exoccipitals, which form a convexity in the median line to receive the vermis of the cerebellum, and on each side of this is a shallow depression. The paroccipital processes are short, narrow, and antero-posteriorly compressed and flattened. The condyles are rather small, low, and depressed, but quite strongly divergent from each other; the foramen magnum is small and subcircular in shape. The supraoccipital is high and almost pointed at the summit, though its shape varies in the different species; its upper portion is diploëtic, filled with cancellate tissue, and develops a bony tentorium. The exoccipitals are separated from the lambdoidal crest by a broad surface of the periotics, terminating distally in small rugose mastoid processes, which, like the paroccipital processes, stand but little in advance of the condyles. The tympanic is loosely attached to the skull, and is very generally missing from the specimens; when present, it is a small and moderately inflated bulla. The external auditory meatus is imperfectly ossified, and forms but a partial tube.

The *basisphenoid* is quite long, broad at the suture with the basioccipital but narrowing forward. The presphenoid is narrow and but little of it is displayed, even when the palatal tube is broken away, since it is largely concealed by the vomer. The alisphenoid is quite large, but forms only a limited part of the side wall of the cranium; near its anterior edge is an oblique overhanging ridge, which runs forward and upward, and is continued upon the frontal, until it passes into the postorbital process. The pterygoid process of the alisphenoid is large and approaches near to its fellow of the opposite side, being in most of the species separated only by the narrow cleft of the posterior nares. In *H. leptocephalus* there is a sutural union between the two processes, concealing the pterygoids and causing the posterior nares to open backward rather than downward. The limits of the orbitosphenoids are not clearly visible in any of the specimens, but it is obvious that these bones must have been small.

The *parietals* are very long and form almost the entire roof of the cerebral chamber. Their breadth varies in the different species, being least in *H. horridus*, greatest in *H. crucians* and *H. leptocephalus*, while *H. cruentus* is intermediate in this respect. In front of the squamosals the parietals become much broader and articulate with the alisphenoids. The sagittal crest is long and very thin and, for most of its length, high, especially toward the hinder end, where the obliquity of the cranial cavity leaves space for it. The postorbital constriction is at or behind the fronto-parietal suture, except in *H. crucians* and *H. leptocephalus*, in which it is in advance of that suture.

The *squamosal* is very large, making up most of the side of the cranial wall, and forming with the supraoccipital the sharply compressed and prominent lambdoidal crest, which the exoccipital appears not to reach. The height of the squamosal varies in the different species, being, of course, the converse of the parietal width, and is, therefore, greatest in *H. horridus*, and is least in *H. crucians*. The root of the zygomatic process is placed very low down near the base of the cranium; it is heavy and massive, and projects well out from the side of the skull, but the anteriorly directed portion is short and remarkably light. The glenoid cavity is broad and concave in both directions; the postglenoid process is highest internally and continues as a low ridge for nearly the full width of the cavity; the preglenoid ridge is but feebly indicated, and in the small species not at all. The jugal is long, slender, and nearly straight, not arching upward, but continuing back in the line of the peculiar maxillary alveolar process; it passes beneath the zygomatic process of the squamosal, and extends as far back as the glenoid cavity, but external to it. The jugal attains its greatest vertical depth at the point where it reaches the maxillary, from which point it tapers anteriorly and forms a very narrow suture with the lachrymal. There is no postorbital process on the jugal. As a whole, the zygomatic arch is remarkable for its length, slenderness, and straightness, and for its low position on the skull, the high, compressed, and isolated posterior region of the maxillary forms a part of it, and thus the last upper molar appears to be implanted in the zygomatic arch. The very curious physiognomy of the *Hyænodon* skull is largely due to the peculiar character and position of this arch. In view of the large and powerful teeth and the profound masseteric fossa of the mandible, this weakness of the arches is exceptional.

As in the creodonts generally, the *lachrymal* is largely expanded on the face in front of and beneath the orbit. In most specimens the lachrymal bears a shallow pit, or depression, bounded behind by the elevated orbital margin. The foramen is within the orbit and single.

The *frontals* are very large, lozenge-shaped bones. In most of the species they cover only the olfactory lobes, and are excluded from the cerebral fossa, but in *H. crucians* and *H. leptocephalus* they take a small share in forming the roof of this fossa. In all the species each frontal is transversely convex, with a more or less well-marked shallow depression between them. This convexity is due to the presence of large frontal sinuses, the development of which varies in the different species, being greatest in *H. horridus* and *H. cruentus*, and least in the small species. The fronto-parietal suture is quite straight, and the sagittal crest is continued forward for some distance upon the frontals, where it bifurcates to form the supraorbital ridges; these are best marked in *H. crucians;* in the other species they are inconspicuous. The postorbital process is quite prominent, but leaves the orbit widely open behind. Anteriorly the frontals diverge to receive the nasals between them, but usually there are no long and pointed nasal processes, though such processes occasionally occur in *H. horridus.*

The *nasals* are very long, broad and transversely convex. Posteriorly they are wedged in between the diverging frontals, and attain their greatest breadth at the fronto-maxillary suture. The differences exhibited by these bones in the various species of the genus affect chiefly the length of the portion enclosed between the frontals; this is greatest in *H. horridus* and least in *H. leptocephalus;* in the latter the broadening at the fronto-maxillary is but slight, while in *H. paucidens* it is very marked. The free end of each nasal is deeply notched and the approximated median projections extend over the edge of the narial opening. The mesethmoid is exceedingly large, even more so than in the carnivorous marsupials; its size is most marked in the vertical dimension, owing to the great height of the nasal chamber, which, however, varies in the different species, and is relatively greatest in *H. horridus.* The vomer is long and high, and the ethmo-turbinals are well developed and complexly folded; the maxillo-turbinals are not displayed in any of the specimens.

The *premaxillaries* are shaped much as in the *Canidæ*, and enclose a narial opening of similar form and relative size; the alveolar portion is thick and heavy, but short, the incisors forming a nearly straight transverse row. The ascending ramus is narrow, and does not reach the canine, which is entirely within the limits of the maxillary. The nasal process of the premaxillary is quite short in most of the species, but in *H. horridus* and *H. crucians* it is elongate and very slender, though, owing to the shortness of the nasal process of the frontal, the two are much more widely separated than in *Canis.* The palatine processes have but a very limited extent, and the incisive foramina are small, hardly encroaching upon the maxillaries.

The *maxillaries* are of great size, and make up nearly the whole of the side-walls of the face and nasal chamber; their height is greatest at the orbits, and diminishes gradually to the front. The two dental series diverge strongly backward, and the distance between the last molars of the two sides is three times as great as that between the first premolars. The alveolar portion which contains the last molar is a deep, compressed bar, which is separated from the palate by a very wide interval, and seems to belong to the zygomatic arch rather than to the jaw, an arrangement which is quite unique among mammals. In consequence of this the last lower molar extends behind the bony floor of the orbit and, when the jaws are closed, rises well above that floor, necessitating, doubtless, some special modification of the soft parts to provide for its reception. The palatine processes of the maxillaries are very long, and anteriorly are quite narrow, and broadening posteriorly, they reach their greatest width at $\underline{p^4}$, behind which they are reduced to narrow strips by the palatines. The elevation of the alveolar borders makes the hard palate somewhat concave transversely.

The *palatines* are broad in front, where they unite in a semicircular suture with the maxillaries; behind this expansion they contract to form a long, narrow tube, and the two bones are suturally united for most of their length, notched only at their hinder extremities by the narrow, slit-like posterior nares. In *H. leptocephalus* the palatines are in contact throughout, and the canal appears to have no inferior opening at all. Such an extreme degree of backward shifting of the narial aperture is very rare among mammals, and is equalled only by the condition attained in the edentate genus *Myrmecophaga*. The pterygoids are but little exposed, as they are, to a great extent, covered up by the pterygoid processes of the alisphenoids. They are low, short, and curved, so as to continue the tubular shape of the palatines, and inferiorly are separated only by the posterior nares, which are somewhat broader here than between the palatines. In *H. leptocephalus* the two pterygoids would appear to be in actual sutural contact. There are no distinct hamular processes, their place being indicated merely by rugosities.

In all the American species the *mandible* has a long and shallow horizontal ramus, the lower border of which is gently and regularly curved from beneath the masseteric fossa to the incisive alveolus. *H. crucians* and *H. paucidens* form partial exceptions to this statement; in the former species the lower border beneath the masseteric fossa is straight, the curvature beginning further forward, while in the latter the face is shorter, and the symphyseal region of the mandible more steeply inclined than in the other American species. In all the symphysis is narrow and very long, extending back to $\overline{p_3}$, and at an early period the two rami are firmly ankylosed in this region. The differences to be noted between the various species appear chiefly in the posterior part of the mandible and in the ascending ramus. In *H. horridus* the coronoid process is high and pointed, slightly recurved, with a concave posterior border, and with the summit placed far in advance of the condyle (see Leidy, No. 2, Pl. III); in *H. cruentus* the process is similar, but has a broader summit; in *H. paucidens*, *H. crucians*, and *H. leptocephalus* the summit is still wider, the posterior border is straight and nearly vertical, and rises very near to the condyle. The masseteric fossa is large and deep with borders parallel to those of the jaw; it is less profoundly impressed, and extends less anteriorly in *H. crucians* than in the other species, while in *H. mustelinus* it is deep, but rather small vertically. The condyle is much extended transversely and placed very low down, below the level of the molars; it occupies the lowest position in *H. crucians*, and in *H. cruentus* stands higher than in *H. horridus*. The angle forms a stout hook, which is best developed and descends farthest below the level of the inferior border of the ramus in *H. cruentus*, least so in *H. crucians*.

Cranial Foramina. The optic foramen is placed quite far back of the orbit and is followed after a short interval by the foramen lacerum anterius, and this, after a similar space, by the foramen rotundum. These three foramina are of nearly the same size, and are all enclosed in the groove formed by the oblique ridge already mentioned. which runs downward and backward from the postorbital process across the frontal, orbito- and alisphenoid. *H. paucidens* differs from the other species in the fact that the foramen lacerum anterius and the foramen ovale are very closely approximated and open almost side by side. The foramen ovale is separated by a wide interval, both from the foramen rotundum and from its fellow of the opposite side. There is no alisphenoid canal in any of the American species. The foramen lacernm medium and foramen lacerum posterius are situated much as in the dogs, at the front and hind edges of the tympanic bulla; the carotid canal appears to be fused with the latter; at all events, I have seen no specimen in which it is distinct. The condylar foramen perforates the basioccipital well in front of the condyle. The postglenoid foramen is distinct, as is also the stylo-mastoid, and the supraoccipital is perforated by two venous foramina. The posterior palatine foramina perforate the palatines, in each of which are three openings, a larger one which opens near the maxillary suture, and behind it two much smaller ones, just such as Schlosser has described in the European species: "Die Gaumenbeine weisen zwei grössere Durchbrüche auf, dahinter noch je zwei kleinere Foramen" (No. 5, p. 175). The infraorbital foramen is a high, narrow oval, and placed above P^3. According to Filhol (No. 1, p. 19) there are some important differences in the arrangement of the cranial foramina found in the European species, at least in *H. brachyrhynchus*, from that above described. The foramen lacerum posterius is distinct from the carotid canal and perforates the basioccipital, and an alisphenoid canal is present. These are the most significant differences regarding the foramina between the species of the Old and New Worlds.

Measurements.

	H. sp.	H. horridus, No. 1.	H. horridus, No. 2.	H. cruentus, No. 1.	H. crucians.	H. paucidens.	H. mustelinus.
	M.						
Skull, length from occipital condyles to incisive alveolus	0.209	0.290	0.310	0.232	0.172	0.170	
" " from for. mag. to front of orbit . .	.121	.144	.172	.130	.114	.101	
" " of face from orbit to incisive alveolus .	.092	.140	.143	.108	.067	.073	.055
" breadth across zygomatic arches . . .	.114			.140			
" length of sagittal crest	.072	.103	.117	.091	.077	.071	
" height of occiput		?.060		.067			
" breadth of occiput at mastoid processes . .	.064		.100	.079	.054		
Mandible, length from condyle	.166	.270	.280	.203	.148	.133	
" height of coronoid process . . .	.058	.077		.060	.054	.047	
" " of condyle	.028	.030	.050	.034	.020	.022	
" depth at m^3		.042	.055	.038	.027		.017
" " at p^2	.025	.037	.056	.028	.021		.015

III. THE VERTEBRAL COLUMN.

The *atlas* is short and broad; the anterior cotyles for the occipital condyles are very deep, extending far back into the cavity of the neural canal, but they are not so strongly concave as in many of the recent carnivores. The neural arch curves upward very decidedly, giving relatively great vertical diameter to the bone; its antero-posterior breadth is rather small, but its thickness is unusually great. This arch has a nearly smooth dorsal surface, without ridges or any trace of a neural spine, but perforated by foramina for the first pair of spinal nerves. The inferior arch of the atlas is narrow from before backward, hardly more than half as wide as the superior; it curves downward as strongly as the neural arch does upward and thus the opening of the atlas is nearly circular. A rudimentary, backwardly directed spine represents the hypapophysis. The posterior cotyles for the axis are large and transversely curved, the two together describing nearly a semicircle. The transverse processes are straight and not very largely developed, especially from before backward, though they give great width to the bone. The vertebrarterial canal perforates the hinder edge of the transverse process, and after a short course opens into a depression on the ventral side. (In my former paper it was incorrectly stated that this canal was not present.) The forward extension of the transverse process converts the atlanteo-diapophysial notch into a foramen. The processes project outward with hardly any recurvature, and this fact gives to the atlas its characteristic shape, quite different from that found in most of the carnivores.

The *axis* is a rather remarkable bone. Its centrum is of only moderate length, but broad and very much depressed, with distinct ventral keel ending in a hypapophysial tubercle behind. The dorsal surface of the centrum, forming the floor of the neural canal, also bears a strong median ridge. The atlanteal facets are low and wide, of oval shape, and with convex surfaces. Like the corresponding facets of the atlas, the outlines of the two together describe nearly a semicircle, very much as in the badger (*Meles*) to the axis of which, indeed, that of *Hyænodon* bears a close general resemblance. The odontoid process is very long and prominent, and of irregularly conical shape, tapering to a blunt point. The transverse processes are short, compressed and slender; they are directed backward and but little outward, and are perforated by the relatively large vertebrarterial canals. The neural canal is higher and narrower in front, broader and lower behind. The pedicels of the arch are thick and heavy, but narrow antero-posteriorly, leaving considerable open space between themselves and the atlas. The neural spine forms a large, thin, hatchet-shaped plate, which, though not very high, is of great fore-and-aft extent, and much exceeds the length of the centrum, beyond which it projects at both ends. The hinder border of the spine is thickened, especially in *H. horridus*. The postzygapophyses of the axis are of moderate size.

The third *cervical vertebra* is decidedly opisthocœlous; it has a short, broad, heavy and depressed centrum, with distinct ventral keel. The neural canal is very low and wide, and the dorsal surface of the arch nearly flat. The zygapophyses, and especially the anterior pair, are very widely separated and present almost vertically. The neural spine is very little developed, the great overhanging spine of the axis leaving hardly any space for it. The transverse process forms a thin, compressed plate considerably longer than the centrum, from which it diverges at a wide angle. The fourth vertebra is like the third, with all its peculiarities exaggerated; it is shorter, heavier, with faces more oblique to the long axis of the centrum; it has a lower, broader neural arch, and more widely separated zygapophyses. The free margin of the transverse process is strongly concave, instead of straight, and hence the process is partially separated into anterior and posterior portions. The neural spine is slightly higher than on the third. The fifth and sixth cervicals differ only in minor details from the fourth, the principal changes being the gradually increased height of the neural spines and the narrowing of the neural arch and canal. On the seventh vertebra the spine becomes relatively very high; the centrum is short, broad, and depressed, the transverse process heavy, straight, and imperforate.

As a whole, the neck of *Hyænodon* is surprisingly short and light, when compared with the size of the head, the skull considerably exceeding the neck in length. The small size of the processes on the cervical vertebræ is evidence that the neck could not have been so heavy and muscular as in most of the recent Carnivora.

The *thoracic vertebræ* number fourteen and, like the cervicals, are proportionately small and weak. In the anterior region the centra are short, gradually increasing in length as we pass backward. The first thoracic vertebra has very prominent transverse processes, which bear very large, concave facets for the tubercles of the first pair of ribs. The second thoracic has similar, but somewhat smaller processes, and on the other vertebræ they become of the ordinary size, though conspicuous on all, except the last two. The size of the spines varies in the different species; in *H. horridus* they are relatively very heavy, while in the smaller species they are light and delicate. In height and in backward inclination they decrease posteriorly, the 11th being the anticlinal vertebra, while the 12th, 13th, and 14th have low spines of the lumbar type, inclining forward. The change in the character of the zygapophyses occurs on the 12th vertebra; those of the posterior thoracics, however, differ from those of the lumbars in being flatter and less cylindrical, and in having smaller metapophyses. Anapophyses appear on the 12th, and become very large on the 13th and 14th.

The *lumbar vertebræ* differ considerably in the various species, but in all the species these vertebræ are relatively the most robust and best developed of the entire column. The only complete series in the collection belongs to an undetermined species, and in this specimen there are seven lumbars. There is no reason to assume a different number for the other species. In *H. horridus* the lumbars have very large centra, which are broad, depressed, slightly opisthocœlous and provided, except the last one, with keels; the transverse processes are long, but not very broad; they are curved sharply forward and terminate in a point. The spines are high, have great antero-posterior extent and incline strongly forward, though that of the last vertebra is nearly erect. The prezygapophyses are exceedingly concave, curving far over, and into them fit the convex, nearly cylindrical postzygapophyses. The metapophyses are small, and on the last three vertebræ rudimentary. In this species the loins are not far from being as heavy and powerful as in the wolves. In the small, undetermined species the lumbars are relatively smaller and lighter, the neural spines are low, compressed and thin; the zygapophyses are more cylindrical in shape, and interlock more perfectly than those of the posterior thoracic vertebræ of the same specimen, but less so than in the lumbars of *H. horridus;* the anapophyses are largest on the 1st vertebra, becoming rudimentary on the 4th, and are absent from the last three. In *H. cruentus* the lumbars are intermediate in character between those of the two species above described. On the last lumbar, however, occurs a peculiar structure, which may be only an individual variation; the transverse process is short, but much extended antero-posteriorly, and abuts against the ilium, forming functionally a part of the sacrum, though no ankylosis with it exists. The process on the left side is much larger than on the right, and has a more extended contact with the ilium; a deep notch divides the process into two parts, the hinder one of which bears a large concave facet for the sacrum, which also is confined to the left side.

The *sacrum* in young animals consists of only two vertebræ, to which in the fully adult form a third is added. The 1st sacral has a broad, depressed centrum with very large pleurapophyses, which carry the ilia almost entirely, the 2d vertebra having but a very limited contact with those bones. In *H. horridus* the 1st sacral has long and heavy transverse processes, which are quite distinct from the pleurapophyses, and are directed obliquely forward; in *H. cruentus* these processes are much smaller, but still blunt and massive. The prezygapophyses of the 1st vertebra are of the same pattern as those on the lumbars, but much lower; the neural canal is also very low, though quite as capacious as in the last lumbar. The spine is well developed and erect. The 2d sacral has a much narrower centrum than the 1st and all its processes are less developed, except the neural spine, which in some cases is larger and heavier than that of the 1st. In *H. mustelinus* the spines of the sacrum are rudimentary. The 3d vertebra has a shorter and wider centrum than the 2d; its processes are rudimentary, but, at least in *H. horridus,* the spine is still prominent.

The *caudal vertebræ* are seldom preserved in any considerable numbers. One specimen, however, belonging to the American Museum of Natural History, has several vertebræ from all parts of the tail, which give an excellent idea of its proportions. These show that *Hyænodon* had a tail of relatively feeble development; the character of the vertebræ is of distinctly carnivorous type, resembling those of the cats, though on a very much smaller scale. The anterior caudals have short, broad, and somewhat depressed centra, with short, wide and nearly straight transverse processes. The neural arch is much shortened antero-posteriorly and the zygapophyses are rudimentary. Passing backward, the centra become more elongate and much more slender and cylindrical in shape, contracted in the middle and more expanded at the ends, without neural arches and with all processes rudimentary. In the terminal region the centra become exceedingly elongate and slender cylinders.

MEASUREMENTS.

	H. SP.	H. HORRIDUS, No. 2.	H. HORRIDUS, No. 3.*	H. CRUENTUS, No. 1.
	M.			
Atlas, length (in median line)	0.018			0.017
" width			.102	.081
Axis, length of centrum	.022	.042	.039	.029
" " of odontoid process				.015
" " of spine (antero-posterior)	.033			.056
Third cervical, length of centrum		.034	.027	.023
Fourth " " "		.029	.028	.021
Fifth " " "	.017	.026		.019
Sixth " " "	.017		.027	.019
Seventh " " "	.016			.021
First thoracic, length of centrum	.016		.024	.021
" " width, posterior face	.021		.029	.025
Tenth thoracic, length of centrum	.016			.020
Fourteenth " " "	.020			.024
Second lumbar, length of centrum	.022	.031	.035	
" " width "	.019	.028	.026	
" " height of spine	.014		.028	
Fourth " length of centrum	.025		.032	.028
Seventh " " "	.022		.031	.022
Sacrum, length (2 vertebræ)			.047	.037
Anterior caudal, length of centrum			.019	.015
" " width "			.016	.013
Median caudal, length of centrum				.022
" " width "				.010
Posterior caudal, length of centrum				.019
" " width "				.006

* *H. horridus*, No. 3, is the fragmentary skeleton belonging to the Museum of Comparative Zoology, Cambridge, Mass., described in my first paper.

IV. THE RIBS AND STERNUM.

The anterior ribs are very broad and flat; this flattening is marked as far as the 6th, behind which they become much more slender and rounded. The 1st rib is especially broad and flattened, and in *H. cruentus* is very much curved as well; the tubercle is exceedingly large and convex, it rises high above the neck and fits into the very prominent transverse process of the 1st thoracic vertebra. The 2d has a similar but smaller tubercle. The other ribs have less conspicuous and somewhat saddle-shaped tubercles which diminish in size posteriorly, and on the 12th become obsolete.

The first segment of the sternum, or manubrium, is of decidedly peculiar type. It is very long, slender, compressed, and of trihedral shape; the dorsal surface is flattened and narrows in advance of the rib-facets to the bluntly rounded anterior end; the ventral side is nearly straight and forms a sharp edge, while the lateral surfaces are wider than the dorsal and are slightly concave. The facets for the 1st pair of sternal ribs form large, prominent, and rounded tubercles; the anterior end projects far in advance of them and they are considerably in front of the joint between the presternum and the first segment of the mesosternum. Among the recent Carnivora with which I have been able to compare this manubrium, that of the viverrine genus *Herpestes* shows the nearest resemblance to it. The segments of the mesosternum are short and heavy; somewhat contracted and of cylindrical shape in the middle, expanded, massive and of more quadrate shape at the ends. The number of these segments is not known at present.

V. THE FORE-LIMB.

The *scapula* is remarkably small, not only in proportion to the size of the skull,

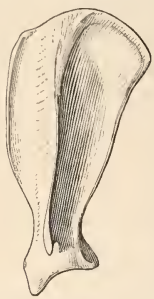

FIG. 1.—*Hyænodon cruentus;* Left scapula, ½ natural size.

FIG. 2.—The same, seen in profile from the anterior side.

but also relatively to the length of the vertebral column, and it has certain peculiarities which do not occur in any of the recent Carnivora. In general shape the scapula of *Hyænodon* is most like that of the dogs; its outlines are all curved and more or less sinuous, somewhat as in *Viverra*, which it also resembles in its relative narrowness and height. The glenoid cavity is somewhat feline in shape, and forms an elongate narrow oval, the antero-posterior diameter considerably exceeding the transverse. The coracoid process is relatively very large, though compressed and but little recurved. The neck of the scapula is short and broad, and the coraco-scapular notch is obscurely indicated; on the anterior face of the neck are depressions for muscular attachments, which are especially well marked in *H. horridus*. Above the neck the coracoid border curves upward and forward, and then gently backward to its junction with the suprascapular border. The latter is also curved, though in somewhat irregular fashion, the posterior part descending more rapidly than the anterior, and its highest point is considerably back of the spine. The glenoid border is somewhat shorter than the coracoid border, and has a concave outline. The spine is set nearly in the middle of the blade, dividing it into pre- and postscapular fossæ of approximately equal size. The spine best exhibits its peculiar shape when viewed in profile from the front. Looked at in this way, it is seen to rise gradually from the suprascapular border, maintains a uniform height for most of its course, and then curves up (*i. e.*, toward the external side, when the bone is in its natural position) to form the prominent and curious acromion. The latter is a compressed and plate-like projection, which extends externally and distally, though not reaching or overhanging the glenoid cavity. There is no trace of a metacromion, and the acromion is not in any way flattened, depressed or retroverted; it thus differs very markedly from the type of structure found among the true Carnivora. The spine, as a whole, is slightly recurved, which gives it a convex anterior and concave posterior face; distally it extends nearly to the glenoid cavity.

The *humerus* is short and weak in proportion to the size of the animal; aside from this it is distinctly canine in character. The head is relatively large and antero-posteriorly is nearly hemispherical, though much less strongly convex in the transverse direction; it presents backward almost as much as proximally. The external tuberosity is high, rugose and massive, but does not extend across the entire anterior face of the bone. The internal tuberosity is small and laterally compressed, with a roughened face, while the bicipital groove is widely open and not very deeply incised. The proximal portion of the shaft is laterally compressed, but of great fore-and-aft depth; distally it contracts to an almost circular section, below which it is moderately expanded transversely. The development of the deltoid ridge varies much; in *H. horridus* it is very prominent, as much so relatively as in the cats, while in the smaller species, especially in the smallest, *H. mustelinus*, it is very inconspicuous and less projecting than in the dogs. The supinator ridge is low, particularly in the smaller species, in which it is hardly more than indicated. The external epicondyle is but little developed, while the internal one is quite prominent, and is perforated by a large foramen. The supratrochlear fossa is broad and deep, much larger than the anconeal fossa, which, though deep, is notably small; the two communicate by a large opening, which appears not to be present in the European species. In the American members of the genus the trochlea is ungulate rather than carnivorous in character, having attained great vertical height. It is divided into three facets, of which the inner one is both the widest and the highest, while the outer one is very narrow; the median facet is a broad and strongly convex "intercondylar ridge." De Blainville's figure (*Subursus*, Pl. XII) shows that in *H. brachyrhynchus* (*Taxotherium parisiense*) the trochlea is much lower, with the intercondylar ridge very obscurely marked, and is altogether quite feline in appearance. This marks a strong contrast between the American and European species of *Hyænodon*, a contrast which may also be observed in many other parts of the skeleton.

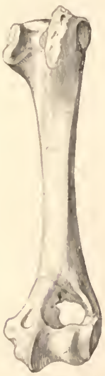

FIG. 8.—*Hyænodon cruentus*; Left humerus, from the front, ½ natural size.

The bones of the fore-arm display a considerable degree of variation among the different species. In *H. horridus* the ulna is relatively short, but massive and not at all reduced. As is so very generally the case among the creodonts, the olecranon is very high; it projects quite strongly backward and terminates in a heavy, rugose, and club-shaped swelling, which overhangs somewhat toward the internal side; it is not grooved by a tendinal sulcus. The sigmoid notch is high and deep, and the coronoid process is very prominent. The notch is somewhat oblique with reference to the long axis of the bone, inclining downward and inward. Except proximally, the humeral surface is confined to the inner half of the sigmoid notch, but there is a small distal external facet for the humerus, which presents upward. The radial facet forms an uninterrupted concavity, the ends of which project beyond the sides of the shaft; the projection on the outer side is much the more prominent of the two. The shaft is laterally compressed, but very stout, rounded and convex on the inner side, deeply channelled on the outer. Its principal diameter is the antero-posterior one, which gradually diminishes downward, while the transverse breadth remains nearly constant throughout. The backward projection of the olecranon gives to the hinder border of the shaft a concave profile. Above the distal end the shaft increases somewhat both in breadth and thickness, and again contracts to form the cuneiform facet, which is wide, thin and convex in both directions. The radial facet is convex and sessile.

FIG. 4.—*Hyænodon cruentus*; Right ulna, from the external side, ½ natural size; part of the distal end is missing.

In *H. cruentus* the olecranon has but a slight backward projection, and, though very high and erect, has no great antero-posterior extent; the tendinal sulcus is much better marked than in *H. horridus*, and the channelling of the outer side of the shaft carried much farther distally. The posterior border of the shaft is less concave and more sinuous in curvature, and the distal expansion is remarkably thick and heavy; in some specimens much exceeding in diameter any other part of the shaft. This expansion is proportionately much larger in *H. cruentus* than in *H. horridus*, and in consequence, the distal end tapers more abruptly to form the cuneiform facet.

In *H. mustelinus* the convexity of the inner side of the shaft, and grooving of the external side, attain their maximum degree, and this is accompanied by a great reduction in the breadth of the bone. As would naturally be expected, the ridges and processes for the attachment of muscles and ligaments are much more prominent in the large species.

The *radius* is less subject to differences among the various species, except so far as the proportionate thickness of the shaft is concerned. The head is transversely expanded, occupying the whole width of the humeral trochlea, but is much compressed from before backward and is thus oval rather than discoidal in shape. The surface for the humerus is divided into three facets, which are all continuous with one another and marked only by a change of shape. Of these facets the largest is the internal one. which is convex transversely and concave antero-posteriorly; the median one is a shallow, rounded pit for the intercondylar protuberance of the humerus, while the external facet is small and nearly plane. Such an elbow joint as that here described cannot have allowed any greater degree of pronation and supination than exists among the dogs. The ulnar facet of the head is a single broad, convex band, uninterrupted by any sulcus. The bicipital tubercle is so inconspicuous that its position is somewhat uncertain. The proximal portion of the shaft is wide but very thin, gradually increasing in thickness and decreasing in width downward, until it becomes nearly cylindrical in shape. The distal portion of the shaft is much heavier than the proximal and of more trihedral section, having a sharp edge on the external or ulnar side, and on the inner side is a broad and deep tendinal sulcus. As a whole, the radius has an irregular double curvature, both anterior and lateral. The carpal surface is a simple concavity, which shows no sign of a division into facets for the scaphoid and lunar; it is deepest on the outer side, contracting toward the inner, and the inner angle is prolonged into a recurved hook, which projects over the tendinal sulcus already mentioned. The radius is relatively heaviest and best developed in *H. horridus;* in the smaller species it is more slender in proportion, and in *H. mustelinus* is exceedingly so, much less heavy than the ulna. The slenderness of the radius and the large size of the ulna in *Hyænodon* are in notable contrast to the proportions which are to be found in the recent Carnivora.

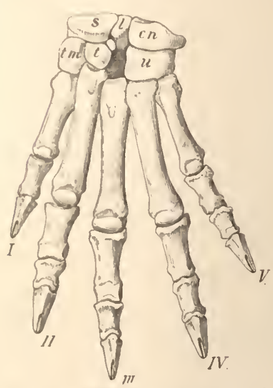

FIG. 5.—*Hyænodon horridus;* Left manus, from the dorsal side, *s*, scaphoid; *l*, lunar; *cn*, cuneiform; *tm*, trapezium; *t*, trapezoid; *u*, unciform. The central appears between the lunar and trapezium. One-half natural size.

The *carpus* of the American species of *Hyænodon* has some constant differences from that of the European species. In the latter the scaphoid, lunar and central appear to be always united, while in the American forms they are as constantly separate and show no tendency to ankylosis. In my former paper I stated that de Blainville's drawing (*Taxotherium parisiense*, Ostéographie, Subursus, Pl. XII) seemed to show the impression of a distinct lunar. Since writing that suggestion, however, I have had an opportunity of examining the original specimen in the Paris museum and find the supposed lunar to be a displaced magnum. Of the American forms I have seen the carpus in *H. horridus* and *H. cruentus* and, except in the matter of size, find no noteworthy difference between the two species.

The *scaphoid* is wide and thick in the dorso-palmar direction, but very low vertically; seen from above, it is of irregular subquadrate outline. The radial facet is convex antero-posteriorly and descends low upon the dorsal face of the bone; it also rises somewhat toward the ulnar border, where the height of the scaphoid reaches its maximum. This facet occupies only a part of the proximal surface of the scaphoid; on the palmar side of it is a broad shelf-like expansion with a roughened surface. On the distal side are three distinctly separated facets, for the trapezium, trapezoid and central respectively, the magnum having no contact with the scaphoid. The facet for the trapezium is very large, much the largest of the three, of irregular shape and nearly plane. That for the trapezoid is much the smallest, and descends in front to a lower level than the others, rising somewhat toward the palmar side, and is of triangular shape. The surface for the central is much larger than the trapezoid facet, on the palmar side of which it comes in contact with that for the trapezium; it is very oblique in position, presenting almost as much toward the ulnar side as distally; in front it is narrow, becoming broader and more concave behind. These three facets do not occupy the entire distal end of the bone, though they take up more of it than the radial facet does of the proximal end; behind them is a similar, but smaller, rugose expansion. On the ulnar side of the scaphoid is a large and slightly convex facet for the lunar, which is cut away behind by that for the central.

The *lunar* is a small bone, inferior to the scaphoid in every dimension except the vertical, in which it considerably exceeds the latter. The radial facet is very strongly convex in the dorso-palmar direction and is reflected farther down upon the dorsal face of the bone than in the scaphoid, but not extending very far toward the palmar side. Behind this radial facet the proximal surface of the lunar descends steeply toward the palmar side, and is quite rugose. The lunar has no distinct facet for the cuneiform, but on its internal side is a concave facet, into which the scaphoid fits, interlocking the two bones very firmly. Distally the lunar bears three facets, for the central, magnum and unciform respectively, all of which are narrow and concave in the dorso-palmar direction. The facet for the central is widest in front, narrowing posteriorly, and is lateral rather than distal in position. The magnum facet is very narrow and somewhat oblique with reference to the dorso-palmar axis of the bone, inclining toward the radial side as it passes backward. The unciform surface is slightly the largest of the three and much the most decidedly concave. The lunar is of almost uniform breadth throughout, in height it increases somewhat to the ulnar side.

The *cuneiform* is a large square bone, considerably exceeding the lunar in size. From the external border it gives off a strong, recurved, hook-shaped process. The proximal surface bears a groove-like facet for the ulna and on the palmar side is a large facet for the pisiform. The distal end is occupied by the facet for the unciform; this is saddle-shaped, being broad and concave on the radial side, becoming narrower and more convex toward the ulnar. The large development of the cuneiform stands in obvious relations with that of the ulna.

The *pisiform* is remarkably large, especially in the vertical dimension. At the proximal end it is expanded transversely and bears two distinct facets, which meet at a very open angle. The surface for the cuneiform is somewhat the wider of the two and is slightly convex, while that for the ulna is concave. From the wide proximal end the pisiform contracts to a compressed neck; the body of the bone is not very thick. but of great vertical diameter; toward the free end it expands, becoming very high, rugose and thick.

The *trapezium* is quite an extraordinary bone. It is of relatively great size, far exceeding the trapezoid and magnum in this respect, and is of irregularly pyramidal shape; the base of the pyramid is formed by the dorsal side of the bone, the apex of which is at the external—proximal—palmar angle. The proximal surface is occupied by the large facet for the scaphoid, which is quite convex transversely, and descends low upon the radial side of the trapezium. On the external or ulnar side are two facets, obscurely separated by a faint ridge. Of these the proximal one, which is the larger and more concave, articulates with the trapezoid; the distal one is L-shaped and articulates with the head of the second metacarpal. On the distal side of the trapezium is a large, oval and concave facet for the head of the first metacarpal; this facet presents obliquely downward and inward and indicates an unusual freedom of movement, perhaps even some degree of opposability, on the part of the first digit.

The *trapezoid* is a rather small bone, though relatively somewhat larger than in the dogs. Its largest area is the dorsal face, from which it tapers to the palmar side, where it terminates in a blunt point. The proximal surface is unequally divided between the facets for the scaphoid and central; the former is small, of triangular shape and slightly convex, the latter much larger and concave. On the radial side is a large facet for the trapezium, but the trapezoid does not extend to nearly so low a level as does the latter. On the distal side is a saddle-shaped surface for the second metacarpal, which is convex transversely and less decidedly concave in the antero-posterior direction.

The *magnum* is not preserved in any of the specimens, but its shape and connections may be confidently inferred from the facets of the surrounding bones. It had no articulation with the scaphoid and was connected proximally only with the lunar and central, more extensively with the former than with the latter. Laterally it articulated with the trapezoid and unciform, distally with the third metacarpal and by a very small facet with the second. In size the magnum must have been one of the smallest bones in the carpus.

The *central* is a curious, wedge-shaped bone; its dorsal face is very small, consequently, when all the carpal elements are in position but little of the central is visible; toward the palmar side it increases rapidly both in height and breadth. As compared with the position taken by this bone in *Mesonyx*, it has in *Hyænodon* been displaced toward the radial side and is for the most part inclosed by the scaphoid and trapezoid, with which it articulates by means of convex facets. It also has quite an extensive contact with the lunar, which, however, is lateral rather than proximal, and a very limited articulation with the magnum.

The *unciform* is very broad, but quite low, in which respects it departs entirely from the typical carnivorous shape; vertically its diameter is less than that of the trapezoid. It is highest on the radial, lowest on the ulnar side. The proximal surface bears facets for the lunar and cuneiform; the former is very much the smaller and is very narrow dorsally, broadening behind; the latter forms a high convexity on the radial side, but descending steeply toward the ulnar side, where the dorso-palmar diameter both of the facet and of the bone itself is much reduced. On the radial surface are two facets for the magnum, the proximal one large and occupying the whole dorso-palmar thickness of the unciform, the distal one very small, of oval shape and confined to the dorsal border. The facet for the unciform process of the third metacarpal is small. On the distal side are large facets for the fourth and fifth metacarpals, that for the latter being somewhat the smaller and more concave of the two. The palmar hook of the unciform is reduced to a mere rough tubercle.

The carpus of *Oxyæna*, which has been described by Osborn (No. 3, p. 108, fig. 9), presents many decided differences from that of *Hyænodon*. The scaphoid is even lower and has a more evenly curved distal border. The lunar is larger, and rests by facets of nearly equal size upon the central and unciform, while it appears to be altogether excluded from the magnum. The cuneiform is much smaller, and has not developed the strong, hook-shaped process from the ulnar border. The trapezium is very much smaller and has a differently shaped facet for the first metacarpal. The central is not displaced toward the radial side and has facets of nearly equal extent (at least on the dorsal side) for the scaphoid and lunar, trapezoid and magnum, and thus its dorsal face is diamond-shaped. The unciform is much higher and narrower and the cuneiform facet is much more oblique; the bone thus is decidedly more like that of the fissipede Carnivora. The peculiarities of the *Hyænodon* carpus are, then, as follows: (1) The large size, especially breadth, of the cuneiform and its ulnar hook; (2) the radial shifting of the central and the consequent articulation of the lunar with the magnum; (3) the great enlargement of the trapezium; (4) the breadth and lowness of the unciform.

The metacarpus consists of five members. The first metacarpal is the shortest of the series, but is heavy and massive, particularly at the proximal end. The head bears a very large and strongly convex facet for the trapezium, the only carpal element with which it comes into contact. Below the facet the head is widened transversely and very thick antero-posteriorly, with a prominent rugosity on the ulnar side, which has no facet for mc. II. Distally to this the shaft contracts, expanding again slightly at the distal end. The trochlea is narrow, asymmetrical and oblique and has but a low carina. The rugosities for ligamentous attachment above the trochlea are low, but the lateral pits, especially the one on the ulnar side, are large and deep. The pollex appears to have diverged somewhat from the direction taken by the other metacarpals, and to have possessed some facility of adduction and abduction.

The second metacarpal is the stoutest of the series and much longer than the first, though not so much expanded at the proximal end. The head carries a saddle-shaped facet for the trapezoid, which is concave transversely and convex antero-posteriorly; on the radial side of the head is a large facet for the trapezium. This articulation of mc. II with the trapezium is very general among the Carnivora, but in none of the recent forms is it so extensive as in *Hyænodon*, just as in this genus the trapezium is of very exceptionally large size. There is a long and prominent magnum process on mc. II, which bears a large facet for that carpal. The contact of mc. II with the magnum is more extensive than that of mc. III with the unciform, and is relatively larger than is to be found in any of the recent carnivores, except the cats. Below the magnum projection is a concavity, into which fits the head of mc. III. The shaft is stout, particularly its distal portion, and in the proximal part is of subquadrate section. The trochlea is low, but wider, more symmetrical and with a heavier and more prominent carina than that of mc. I.

The third metacarpal considerably exceeds all the others in length. The proximal end is rather narrow but much extended in the dorso-palmar direction and carries a facet for the magnum, which is extended and convex in the same direction, narrow and slightly concave transversely. On the radial side of the head is a convex facet for mc. II, which is confined to the dorsal border, while the articulation with mc. IV is by means of two facets which occupy the whole dorso-palmar thickness of the head. Of these facets the dorsal one is large and concave, the palmar smaller, plane and situated at a higher level, becoming confluent with the magnum surface, from which the dorsal facet is divided by the unciform process. The latter process is small, not at all comparable to the size which it attains in the cats; it extends but little over the proximal end of mc. IV, and is confined to the dorsal half of the head. In the figure of the manus of *H. horridus* given in my former paper (No. 6, Pl. VII, fig. 5) this process is restored as much too large, for I was misled by the damaged condition of the head of mc. III in the Cambridge specimen. The better preserved individuals now at hand show that the unciform process of mc. III is much smaller than in *Mesonyx*, or even than in *Oxyæna*, and smaller than the magnum process of mc. II, which is not only more prominent, but extends across the entire thickness of the head. The shaft of mc. III is long and rather slender; its proximal half has the angular, subquadrate form seen in the dogs, while the distal is more oval in section and considerably broadened at the end, though the lateral ligamentous processes are much less prominent than in the cats. The trochlea is broad and symmetrical, the carina being in the median line and better developed than on mc. I and II. The trochlea is but moderately convex, and lower than in the modern digitigrade carnivores.

The fourth metacarpal is shorter and stouter than the third, though longer than any of the others. The head is extended both transversely and anterior-posteriorly and carries a simple convex facet for the unciform. On the radial side are two facets for mc. III, separated by a low ridge; the dorsal one is convex and stands at a lower level, allowing the unciform process to overlap it and reach the unciform, while the palmar facet is flat and higher up, so that at this point the proximal articular surfaces of mc. III and IV lie in almost the same plane. On the ulnar side of mc. IV is a single low and deeply concave facet for mc. V, which extends across the full thickness of the head. The shaft is not so straight as that of mc. III, but curved, with the concavity directed to the ulnar side, and is heavier and of less distinctly quadrate section. Mc. III and IV do not form a symmetrical pair, as they do in *Mesonyx*, *Oxyæna*, *Canis*, *Hyæna*, etc., and the trochlea of the latter is unequally divided by the carina, which is slightly nearer to the radial than to the ulnar side.

The fifth metacarpal is very short, only slightly exceeding the first in length, to which it bears a close resemblance in shape and appearance. The proximal end is considerably expanded, and carries on the ulnar side a prominent rugosity for ligamentous attachments. The facet for the unciform is narrow transversely, but much extended antero-posteriorly, and very strongly convex; it articulates only with the distal side of the unciform and does not extend up upon the ulnar side. The facet for mc. IV is of crescentic shape, the dorsal horn being convex and projecting, while the palmar horn is flat. The shaft is stouter than that of mc. I, more arched and more strongly compressed antero-posteriorly, while the distal trochlea is much broader, especially on the palmar side.

The metacarpus of *Oxyæna* is decidedly different from that of *Hyænodon*. The bones are even shorter, weaker and more slender in proportion to the size of the skull. The digits are disposed more symmetrically, III and IV forming one pair of nearly equal length and weight and, apparently, II and V another pair. In *Hyænodon*, on the other hand, the metacarpals are all of different lengths, the order being III, IV, II, V, I, and they are arranged so as to diverge from one another more than in *Oxyæna*, though much less than in *Patriofelis*. The carpal connections are also different in the two genera. In *Oxyæna* mc. II has an extensive articulation with the trapezium, but does not reach the magnum, while in the White River genus the magnum process is very prominent and the facet large. The unciform process of mc. III is in *Oxyæna* rather small, but decidedly larger than in *Hyænodon*, while the head of mc. V has a concave facet for the unciform, and embraces both the distal and external sides of that bone. The only other creodonts, the structure of whose manus is completely known, are *Mesonyx* and *Patriofelis*; in the former the manus is of an entirely different type, approximating more to the condition assumed by the hyænas, while the latter is not notably different from *Oxyæna*.

The *phalanges* of the various digits in *Hyænodon* differ from one another only in size and in the degree of curvature which they display. The proximal phalanx is of only moderate length, but broad, heavy and depressed. The proximal end is broad and thick, with a shallow articular surface for the metacarpal, which is deeply notched at the palmar border; a notch which would seem to be wider and deeper than necessary for the metacarpal carina which it accommodates. The shaft is broad, stout and strongly arched toward the dorsal side. The distal trochlea is of rather small dorso-palmar diameter and but imperfectly divided into two facets by a median depression; the trochlea does not encroach upon the dorsal face of the bone, but is altogether distal and palmar in position. There is some resemblance between this phalanx and the corresponding one of *Canis*, but the latter is more elongate, more slender, the distal trochlea has a greater palmar prominence and is more deeply depressed in the middle.

The second phalanx is short and depressed, but very broad. The proximal articular surface is distinctly divided into two facets, and deeply emarginated in the median line of the palmar border, but there is no indication of a median dorsal beak, such as occurs in the dogs and in many other carnivores. The distal trochlea is hardly at all divided into two parts by a median depression and is reflected quite far upon the dorsal face of the bone.

The ungual phalanx has a single proximal articular surface, which is deeply concave in the dorso-palmar direction, but without curvature transversely. On the palmar side, below the trochlea, is a large, rough tubercle for tendinous and ligamentous attachments, the subungual process. This phalanx is broad and thick, tapering very gradually to the free end. As is so very generally the case in the creodonts (with the exception of the *Miacidæ*) the ungual is very deeply cleft at the tip and is altogether similar to that of *Oxyæna* and *Patriofelis*.

Measurements.

	H. horridus, No. 2.	H. horridus, No. 3.	H. horridus, No. 4.[1]	H. cruentus, No. 1.	H. cruentus, No. 2.	H. mustelinus.
	M.					
Scapula, height				0.122		
" greatest width				.067		
" height of acromion				.019		
" antero-posterior diameter of glenoid cavity	.037			.028		
" transverse diameter of glenoid cavity	.027			.020		
Humerus, length (from head)		.200?			.150	
" diameter of proximal end (ant. post.)	.063				.046	.022
" breadth of trochlea		.031			.026	
Ulna, length	.218	.200		.161		
" height of olecranon from beak	.046	.047		.029		
" diameter of shaft at radial facet (ant. post.)	.034			.023	.023	.011
" " " distal expansion (ant. post.)	.018			.015	.019	
Radius, length	.160	.150	.147			
" breadth of proximal end		.026	.029	.019		.011
" " distal end	.030	.022	.027	.019		
Carpus, breadth	.050	.043		.030		
" height	.026	.021		.020		
Metacarpal I, length	.034	.034				
" I, breadth of proximal end	.013	.012				
" II, length		.056				
" II, breadth of proximal end		.014				
" III, length	.072	.066?				
" III, breadth of proximal end	.014					
" IV, length	.064	.064				
" IV, breadth of proximal end	.015	.012				
" V, length		.039				
" V, breadth of proximal end		.009				
First phalanx, digit III, length	.030					
" " " " breadth of proximal end	.015					
Second " " " length	.017					
" " " " breadth of proximal end	.013					
Third " " " length						
" " " " breadth of proximal end	.010					

[1] Specimen belonging to the American Museum of Natural History.

VI. THE HIND-LIMB.

The *pelvis* of *Hyænodon* is not especially creodont in character, approximating more the condition found in certain of the Carnivora. In the earlier and less differentiated creodonts, as likewise in the insectivores, the ilium is more or less distinctly prismatic and trihedral in shape, while in *Hyænodon* it is flattened and expanded into a plate, though less so than in some of the recent large genera. So far, complete specimens of the pelvis have been found only in *H. cruentus*, which will therefore be used as the basis for the present description. Fragments belonging to some of the other species indicate that certain differences obtain between them regarding the shape of the ilium. In *H. cruentus* the neck of the ilium is short, deep, and thick; the ischial border rises abruptly to form a quite moderate anterior expansion, with a somewhat concave gluteal surface. The rugose area for the attachment to the sacrum is placed very far back, its posterior margin coinciding with the commencing expansion of the iliac plate. The latter thus extends considerably in front of the sacrum and, when viewed from the side, almost completely conceals the last lumbar vertebra, against the transverse process of which the ilium partly rests. The iliac surface is quite broad posteriorly and somewhat oblique in position; anteriorly it becomes narrower. The acetabular border describes a slight curve, with the concavity downward, which is much less pronounced than in *Canis*, but decidedly more so than in the cats or mustelines. The pectineal process, which among the creodonts is so generally well developed and prominent, is in *Hyænodon* represented by a mere tubercle. The acetabulum is quite large and deep, and its articular surface is but little reduced by the sulcus for the round ligament.

FIG. 6.—*Hyænodon cruentus*; Left os innominatum, ½ natural size.

The ischium is rather short, compressed and plate-like. It does not lie in the same vertical plane as the ilium, but is posteriorly somewhat twisted upon itself and everted, though this eversion and depression are much less marked than in the dogs, and the tuberosity is much less prominent and massive than in those animals.

The pubis is short, straight, broad and very thin. The symphysis, formed partly by the pubis and partly by the ischium, is elongate. The obturator foramen is a long, narrow oval, with its principal axis directed antero-posteriorly. The foramen is considerably more elongate proportionately than in the dogs, which is due to the greater width of the descending process of the ischium in the latter.

In *H. horridus* the ilium is more feline in character; the ischial border does not ascend so abruptly to form the anterior expansion, which is narrower; the acetabular border is less decidedly curved, and the gluteal surface more deeply excavated.

The femur varies somewhat in the different species, being in some considerably more slender than in others, though it is in all strikingly weak as compared with that of the true carnivores. In length it rather exceeds the humerus, but not greatly, less so than is the case in most of the *Canidæ*. The head is small, hemispherical, projecting strongly toward the mesial side, as well as proximally; it is set upon a very distinct neck and has a remarkably small pit for the round ligament. The bridge connecting the head with the great trochanter is narrow and compressed. The great trochanter is massive and roughened, but low, not rising as high as the head and enclosing a small but deep digital fossa. The second trochanter is developed to an unusual degree; it forms a prominent, heavy and rugose pyramid, which is much more pronounced than in the recent carnivores and is more closely connected with the great trochanter by means of an elevated ridge. The third trochanter, which in most of the creodonts is very distinctly developed, has in *Hyænodon* become rudimentary and is not so well marked as in the early dogs and cats; e. g., *Daphænus* and *Dinictis*. The external linea aspera, with which the third trochanter is connected, is also but feebly marked. The proximal end of the shaft is not so much expanded transversely as in the *Canidæ* and, aside from the large size of the second trochanter, the whole upper part of the femur is decidedly more feline than canine in appearance. The shaft is flattened on the posterior face, rounded on the other sides and relatively very slender. In the latter respect, however, there are considerable differences between the species, the larger forms having relatively stouter bones, and even in the same species marked differences occur, which may, perhaps, be of a sexual nature. The shaft of the femur has a double curvature, arching both forward and outward, so that the inner profile, when viewed from the front, is distinctly concave and the outer convex. The distal end is moderately widened transversely and very thick antero-posteriorly, in which dimension it proportionately much exceeds the femur of the wolf. The rotular trochlea is not like that found in the recent carnivores; it is narrow and rather deep, with compressed, sharp and elevated borders, and is reflected far up upon the anterior face of the shaft. The internal border is higher than the external, and the whole structure has a perissodactyl rather than a carnivorous appearance. The condyles are rather small, but project strongly toward the posterior side, and the outer one slightly exceeds the inner one in breadth. The space separating the condyles is slightly narrower proportionately than in *Canis*. As in many of the recent carnivores, there is a small facet on the proximal face of each condyle for a sesamoid bone.

FIG. 7.—*Hyænodon cruentus*; Left femur from the front, ½ natural size.

The *patella* is of oval shape and of no great thickness; its thinning is especially noticeable in the smallest of the species, *H. mustelinus*.

The *tibia* is short, decidedly shorter than the femur, and in general character most resembles that of such recent plantigrade genera as *Procyon*. The condyles are rather small, nearly plane transversely and slightly convex antero-posteriorly. The postero-external angle of the outer condyle forms a broad, overhanging shelf, on the distal surface of which is a large, plane facet for the head of the fibula. The cnemial crest is only moderately developed and is much less prominent than in the *Canidæ*; it extends, however, quite far down the anterior face of the shaft. The proximal portion of the shaft is quite heavy and of trihedral section; it has a double curvature, like that of the femur, arching forward and toward the mesial side; the distal portion of the shaft, on the other hand, is of rounded form and nearly straight. The distal end is but moderately widened and thickened and has nearly equal transverse and antero-posterior diameters. The articular surface for the astragalus is quite well grooved and distinctly divided into two facets, the inner one of which is narrow and deep, the outer one broad, but slightly concave and placed at a very acute angle with the long axis of the shaft. Except at the anterior margin, the intercondylar ridge is low and inconspicuous. This ridge is better developed in *H. horridus* than in the smaller species and the astragalar facets are more deeply impressed. In all the species the malleolar process is prominent and thick antero-posteriorly, though not very long; its distal end bears a facet for a pit on the neck of the astragalus, a character which is very common in the creodonts. The distal fibular surface is not a distinct facet, but merely a groove on the outer side of the tibia.

The *fibula* is relatively little reduced, even less so than in the *Procyonidæ*, except in *H. crucians*, in which, according to Wortman (No. 4, p. 225) it is very slender. The proximal end is very heavy and is expanded both in breadth and thickness; it articulates by a large, plane facet with the lower side of the overhanging external condyle of the tibia, which has been already described, and on its outer face is a deep tendinal sulcus. Somewhat below this enlarged head the shaft is thinnest and most contracted, but it soon expands and gradually, though not regularly, increases in diameter toward the distal end. The double curvature of the tibia produces a wide interval between the two leg-bones, whether seen from the front or the side, and though the shaft of the fibula is nearly straight, its contact with the tibia is restricted to the extreme proximal and distal ends. The distal end of the fibula is highly characteristic of the genus. It is enlarged in both the transverse and antero-posterior diameters, especially in the latter; on the outer side is a broad and prominent, recurved, hook-shaped process, which forms a tendinal groove; on the inner side is a large and plane, or slightly convex, facet for the external face of the astragalus and on the distal side is a facet for the calcaneum. The calcaneal facet, though narrow, occupies the entire thickness (fore-and-aft) of the fibular end. No existing carnivore has such an extensive and elaborate articulation between the fibula and calcaneum as occurs in *Hyænodon*, nor is it found in any other known creodont.

FIG. 8.—*Hyænodon* sp. Distal end of right tibia and fibula of young animal, natural size.

The tarsus is not at all characteristically creodont in structure and although the pes has lost no digits, it is quite as advanced in its way as in any of the Carnivora.

The *astragalus* in all the American species of *Hyænodon* displays certain constant differences from that of the European species (see Zittel, No. 9, p. 584, fig. 587, de Blainville, Ostéographie, Subursus, Pl. XII), the most important of which are the greater obliquity of the external calcaneal facet and the much greater length of the neck in the former. The amount of grooving exhibited by the trochlea varies according to the species. In *H. cruentus* the groove is deep, for a creodont astragalus, less so than in the recent digitigrade carnivores, but decidedly more so than in such White River genera as *Dinictis*, *Hoplophoneus* or *Daphænus*. In the little *H. mustelinus* the trochlea is more flattened, while in *H. horridus* the grooving is better marked than in the existing cats. Between these extremes the contrast is very notable. The degree of symmetry of the astragalar trochlea also differs in the different species. In *H. horridus* and *H. cruentus* the external condyle but slightly exceeds the internal in size, while in the small undetermined species (marked *H. sp.* in the tables of measurements) and in *H. mustelinus* it does so considerably. The fibular facet of the astragalus is large and slightly concave; distally it becomes confluent with the external calcaneal facet, from which it is elsewhere separated by a deep sulcus. The facet on the inner side for the tibial malleolus has but little dorso-plantar depth, but extends well distally, where it terminates in the characteristic pit or fossa which occurs in so many creodonts. The neck is long, especially in *H. mustelinus*, and strongly everted toward the internal side, so that there is no contact, or none but the most limited, with the cuboid. The head bears a rounded, simply convex facet for the navicular; there is no facet for the cuboid (Zittel's figure is incorrect in this regard) and, apparently, the two bones do not meet at all. The head is depressed and flattened, the transverse diameter exceeding the dorso-plantar one. The external calcaneal facet is large and quite deeply concave; its position is oblique with reference both to the dorso-plantar and proximo-distal axes of the astragalus. The sustentacular facet is slightly convex and is everywhere separated from the outer calcaneal facet by a deep sulcus; it is relatively broader than in the European species.

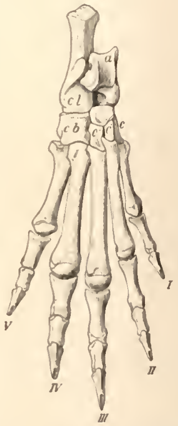

FIG. 9.—*Hyænodon sp.* Right pes: *a*, astragalus, *cl*, calcaneum; *cb*, cuboid; *c′*, *c″*, *c‴*, ento-, meso- and ectocuneiforms. ½ natural size.

The astragalus of *Hyænodon* presents some very marked differences from that of *Oxyæna* and *Patriofelis*. The trochlea is narrower and much more deeply grooved; the neck is longer and directed more toward the tibial side of the foot; the head is narrower, less depressed and has no such extensive articulation with the cuboid, if, indeed, it has any at all.

The *calcaneum* has a rather long tuber, which is deep and compressed, somewhat thickened and rugose at the free end, which is without any distinctly marked tendinal sulcus. The dorsal margin of the tuber is slightly convex and the plantar concave, arching downward to a roughened surface vertically below the fibular facet, whence the border rises to the distal end. The greatest dorso-plantar diameter is thus at the fibular facet; it is a little more distal in *H. cruentus* than in *H. horridus*. In *H. mustelinus* the tuber is relatively shorter than in the large species. The process for ligamentous attachment which arises from the external side near the distal end is quite prominent, especially in *H. horridus* and *H. mustelinus*, though not so much so as in some of the European species (e. g. *H. brachyrhynchus*). The sustentaculum is not very strongly developed and carries a concave, nearly circular astragalar facet. The outer astragalar facet is large and convex and presents more toward the internal than toward the dorsal side; its junction with the fibular facet, which lies in a somewhat different plane and presents distally and dorsally, forms an inconspicuous ridge. The fibular surface is very large and prominent, most exceptionally so for a flesh-eater, and gives to this region of the calcaneum quite an artiodactyl appearance; this facet is elongate and convex and rises very steeply from the body of the calcaneum. So far as can be judged from the published figures, the fibular facet is not so extensively developed in the European species as in the American and the sulcus between the external astragalar facet and the sustentaculum is more deeply incised. The cuboidal facet is quite oblique to the long axis of the calcaneum, inclining distally and to the external side; it is slightly concave in both directions and more or less warped and saddle-shaped.

The calcaneum of *Oxyæna* has a relatively shorter and heavier tuber than that of *Hyænodon*, a much larger and more prominent sustentaculum and a more obliquely-placed cuboidal facet. The most important difference between the two genera, however, consists in the fact that in *Oxyæna* there is no distinct surface for the fibula, the astragalus extending so far over the dorsal face of the calcaneum as to exclude the latter from any contact with the fibula. In the whole creodont-carnivorous series no other genus has yet been found with so extensive and elaborate an articulation between the fibula and the calcaneum as occurs in *Hyænodon*.

The *cuboid* is a large and heavy bone; its greatest diameter is the vertical, or proximo-distal, while the breadth and thickness are nearly equal to each other. The proximal surface is entirely occupied by the large, subquadrate and slightly convex facet for the calcaneum, which is very oblique in position, being highest at the postero-internal angle of the bone and descending steeply from this point toward both the dorsal and external sides. If there is any contact at all with the astragalus, which seems unlikely, it is not sufficient to require a distinct facet. The proximal end of the cuboid is thus entirely different from that found in *Oxyæna* and *Patriofelis*, where the cuboid possesses facets for the calcaneum and astragalus of nearly equal size. These two facets meet at nearly a right angle and thus give to the cuboid a highly characteristic appearance, which is not reproduced in *Hyænodon.* In the latter the tibial side of the bone displays proximally a large flat facet for the navicular, and distal to this two small, round projections for the ectocuneiform, which are separated from each other by a wide and deep sulcus. The plantar hook-shaped process is not long, but very broad and heavy and extends around both the external and plantar surfaces. The distal side has a large, triangular and concave articular surface, which is obscurely divided into facets for the fourth and fifth metatarsals; in *H. cruentus* the latter is very small and somewhat oblique in position; in *H. horridus* it is larger and more entirely distal.

The *navicular* is low and narrow, but with considerable dorso-plantar extension. The astragalar surface is simply and deeply concave. On the fibular side is a large and nearly flat surface for the cuboid, the proximal ends of the two bones lying in nearly the same plane. On the distal side are the usual three facets for the cuneiforms, the only noteworthy feature of which is the narrowness of that for the entocuneiform. The plantar hook is quite prominent; in *H. sp.* it is straight and knob-like, while in the larger species it is longer and more decurved.

The *entocuneiform* is high and thick antero-posteriorly, but very narrow and compressed; it is broadest on the plantar side, thinning to an edge on the dorsal, and the distal end exceeds the proximal in every dimension. The navicular facet is very small, while that for the first metatarsal is considerably larger and strongly concave in the dorso-plantar direction. On the fibular side is quite a large facet for the head of the second metatarsal.

The *mesocuneiform* is low, but exceeds the entocuneiform in the other two dimensions; its distal surface stands at a higher level than that of the tarsals on each side of it, as is very generally the case in both the creodonts and carnivores. The bone is wedge-shaped, but in the opposite sense from the entocuneiform, the dorsal surface being the wider. The lateral facets are small and obscurely indicated.

The *ectocuneiform* is much the largest of the three, except in vertical height, which is less than that of the internal element, though much greater than in the median one. On the plantar surface is a heavy, prominent knob, shaped very much like that on the navicular. On the tibial face are two facets, a proximal one for the mesocuneiform and a distal one for the second metatarsal. The cuboid facets are both proximal; they are small, rounded and separated by a wide sulcus, but are not projecting and shelf-like, as are the corresponding facets on the cuboid. The distal facet for the third metatarsal is not much wider than that on the mesocuneiform for the second metatarsal; it is much extended from before backward and is quite deeply concave in the same direction.

The *metatarsus* consists of five fully developed members; they are rather more slender than the metacarpals and exceed them but little in length. This is an unusual proportion among the flesh-eaters, in which the hind-foot is generally noticeably longer than the fore-foot. Both are short, weak and slender in relation to the size of the animal, though in the larger specimens of *H. horridus* the feet are not quite so disproportionately weak.

The first metatarsal is not so heavy as the corresponding metacarpal, but considerably longer; it has an enlarged head, which is both broad and thick and bears a large saddle-shaped facet for the entocuneiform; on the plantar side is a very prominent knob-shaped process, which extends toward the fibular side of the foot and abuts against the ectocuneiform, for which it has a facet. The proximal portion of the shaft is laterally compressed, but of considerable thickness antero-posteriorly; it soon becomes slender and subcylindrical. The distal trochlea is narrow, of asymmetrical shape, with prominent carina.

Owing to the small proximo-distal diameter of the mesocuneiform, the head of mt. II rises to a considerably higher level than those of mt. I and mt. III, and is wedged in firmly between the ento- and ectocuneiforms, with the latter one of which it has an extensive articulation. On the fibular side the head is excavated to receive that of mt. III. The shaft at first pursues an oblique course, its proximal portion being inclined outward as well as upward, but then turns and most of the shaft runs more nearly parallel with those of the other digits. Something of the same sort may be observed in *Lutra*, but the curvature of the proximal end is less in amount and in the opposite direction. In *Hyænodon* the shaft of mt. II is weak, slender and relatively short; the distal end is but moderately expanded and thickened; the trochlea is asymmetrical and somewhat obliquely placed.

The third metatarsal is the longest of the series and, except mt. IV, the heaviest. The head is narrow and convex from before backward, terminating on the plantar side in a rough knob, which is especially large and rugose in *H. horridus*. On the fibular side of the head is a deep cavity into which is received a rounded articular projection from the head of mt. IV. A second concave facet for mt. IV extends posteriorly to the end of the plantar knob already mentioned. Mt. III and IV are thus very firmly interlocked, while the connection of the former with mt. II is looser. The shaft is slender, nearly straight and of trihedral section, the apex of the triangle being the plantar edge. The distal end is more expanded than in mt. II and the trochlea is wider and more symmetrical, with the carina nearly in the median line. The lateral ligamentous processes above the trochlea are quite prominent.

The fourth metatarsal is somewhat shorter and slightly stouter than the third, but otherwise similar to it. It is closely interlocked with both the adjacent metatarsals, having on the head a deeply concave facet for mt. V and a prominent articular convexity for mt. III. The heads of these three metatarsals stand at nearly the same level, each of them articulating with a single tarsal element. The shaft and trochlea of mt. IV are very much the same as those of mt. III, with which it forms an almost symmetrical pair.

The fifth metatarsal is considerably longer and heavier than the first; the head is distinguished by an unusually large process for ligamentous attachment, which appears on the fibular side. This process is much larger and more massive than in the *Canidæ* or *Felidæ*. The shaft is short, slender and curved, arching toward the tibial side of the foot.

The *phalanges* of the pes differ little from those of the manus. They are only somewhat more slender and elongate, but are relatively shorter than in most recent carnivores.

In the American representatives of the genus *Hyænodon* there is very little variation in the structure of the hind-foot. The preceding description is founded upon well-preserved specimens of no less than four of the species, viz., *H. horridus*, *H. cruentus*, *H. mustelinus* and *H. sp.*, and the only tangible differences between them are those of size, aside from the few minor variations which have already been mentioned, such as the depth of the astragalar groove, the size and massiveness of the various processes for muscular and ligamentous attachments and the like. In the small species also (e. g. *H. sp.* and *H. mustelinus*) the metapodials are somewhat more slender in proportion than those of the larger and more robust forms, but the difference is not a strikingly obvious one. The agreement with the European species is closer in the pes than in the manus, for in the latter the condition of the carpus is quite different in the two groups of species. In the pes the shortness of the astragalar neck, the greater prominence of the external, distal ligamentous process of the calcaneum and the somewhat smaller size of the fibular facet, are almost the only divergences to be noted. Schlosser's figure (No. 5, Pl. V, fig. 47) of the hind-foot of *H. compressus* is, it is true, not very like that of the American species in appearance, but the difference is, doubtless, partly due to the fact that his specimen is built up from many individuals. Comparing the pes of *Oxyæna* and *Patriofelis* with that of *Hyænodon*, the principal difference to be noted consists in the shape of the cuboid, its extensive articulation with the astragalus and the consequent divergence of the metatarsals, and also the absence of any calcaneo-fibular articulation. *Hyænodon* has attained the differentiation of pes which is found in the Carnivora, though without any reduction in the number of digits.

MEASUREMENTS.

	H. SP.	H. HORRIDUS, No. 4.	H. CRUENTUS, No. 1.	H. CRUENTUS, No. 2.	H. CRUENTUS? No. 3.	H. MUSTELINUS.
	M.					
Pelvis, length				0.150		
Ilium, "				.089		
" greatest width				.028		
Ischium, length				.061		
Obturator foramen, fore-and-aft diameter				.037		
Femur, length (from head)			.165	.169		
" breadth of proximal end			.040	.041	.047	
" thickness of distal end			.041	.044		.020
" width of rotular groove			.013	.015		.007
Tibia, length	.133		.146			
" breadth of proximal end	.031		.038		.038	
" " of distal "	.017	.025	.018	.021	.024	
Fibula, length	.123					
" thickness of proximal end	.015					
" " of distal end	.014	.017	.014		.016	

MEASUREMENTS—(*continued*).

	H. SP.	H. HORRIDUS, No. 4.	H. CRUENTUS, No. 1.	H. CRUENTUS, No. 2.	H. CRUENTUS? No. 3.	H. MUSTELINUS.
	M.					
Calcaneum, length		.055			.053	.029
" dorso-plantar depth at free end		.018			.013	.009
" " " " at fibular facet	.023	.032			.024	.014
Astragalus, length	.028	.037	.028		.032	.018
" width of trochlea	.013	.017	.013		.015	.009
" " of head	.013	.016	.013		.013	.008
Tarsus, proximo-distal height (fr. astragalus to mt. III)	.038	.060			.047	.027
Metatarsal I, length		.043				
" I, breadth of proximal end		.010			.007	.004
" II, length		.063				
" II, breadth of proximal end		.010			.008	.005
" III, length	.057	.070			.066	
" III, breadth of proximal end	.008	.011			.010	.006
" IV, length	.056	.069			.065	
" IV, breadth of proximal end	.006	.009			.008	.005
" V, length	.040	.054			.048	
" V, breadth of proximal end	.008	.011			.011	
Phalanges of III digit, length	.045					

VII. RESTORATION OF HYÆNODON.

As a whole, the skeleton of *Hyænodon* presents a curious and remarkable appearance. As compared with any of the recent Carnivora, the head appears large

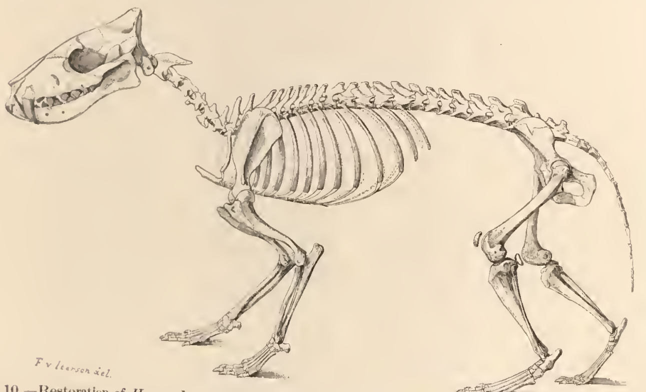

FIG. 10.—Restoration of *Hyænodon cruentus*. The skull, neck, 9 thoracic, 4 lumbar, 2 sacral and 2 caudal vertebræ, scapula, ulna, radius and part of carpus, femur, tibia, fibula and part of pes, belong to a single individual, and were excavated from the same block. The other vertebræ, except those of the tail, were supplied from a specimen in which the vertebral column is complete. 1-7 natural size.

out of all proportion to the body and limbs, the neck short, the back, especially the lumbar region of it, quite long, the tail short, the limbs short and slender, the feet small and weak. The skull has a very characteristic physiognomy, quite different from that of any of the true carnivores. This peculiarity is due to the great length of the cranial region, with its very lofty sagittal crest, to the extreme straightness and slenderness of the zygomatic arches, the position of which is very low down on the sides of the skull; in front the maxillary alveolus forms a part of the zygoma, which thus seems to carry the sectorial molar, a very exceptional arrangement. The region of the cranium back of the glenoid cavity is very short, a feature which is usual among the creodonts. The low position of the zygomatic arches increases the apparent depth of the face, which, independently of this, is very considerable. Other characteristic features of the head are the great length of the mandible, which very nearly equals that of the skull itself, its slenderness and the regular curvature of its inferior border. When the jaws are closed, the lower teeth, except the anterior ones, are concealed from view, the upper molars extending over the sides of the mandible.

The neck seems very short and slender to carry the weight of the large head, its length being hardly more than two-thirds that of the skull. The axis is the only cervical vertebra which is strongly developed and possesses a large spine; the others are weak.

The thorax is small, when compared with the skull, but measured by any other standard, it is quite large and capacious. The vertebral spines are developed much as in the Carnivora and the transverse processes and rib-tubercles are very conspicuous. The lumbar region is long and powerful, the vertebræ having massive centra and long heavy spines, transverse processes, etc. These features are most marked in *H. horridus*, the smaller species having much less massive loins and evidently feebler muscles. The whole back, from the neck to the sacrum, is strongly arched upward and its parts are articulated together with unusual flexibility and strength. The sacrum partakes of the character of the lumbar region, with prominent spines, while the tail is rather short and slender, having about the same proportionate development as in the raccoons.

The scapula is remarkably small and, with many peculiarities, is shaped not unlike that of the dogs. The humerus is short and slender and the fore-arm bones still more so, though the ulna is stout and has, as in nearly all the creodonts, a very prominent olecranon. The manus is relatively small, short and broad, with spreading digits and short phalanges, terminated by heavy claws.

The pelvis is of moderate size, with expanded, flattened ilium, and is carnivorous rather than creodont in character. The femur considerably exceeds the humerus in length, but it is proportionately light and slender and has nearly lost the third trochanter. The tibia is short, though much longer than the radius and the fibula stout, especially at the ends. The pes is small and weak, not greatly exceeding the manus in length. It is very difficult to decide whether *Hyænodon* was digitigrade or plantigrade in gait and several structural characters may be adduced in support of either view. In favor of the plantigrade position may be mentioned the proportions between the arm and fore-arm, as well as those between the thigh and leg, the character of the carpus, the absence of any tendinal sulcus on the free end of the calcaneum, the large size of the pollex and hallux and the fact that the digits do not form symmetrical pairs, but are all of different lengths. On the other hand, the backward projection of the head of the humerus and its position with reference to the line of the shaft, the height of the humeral trochlea, the character of the rotular trochlea of the femur and the position of the femoral condyles, the deep grooving of the astragalus and the length of the tuber calcis, all seem to indicate a digitigrade gait. In the restoration herewith given a semi-plantigrade position, such as occurs in many mustelines and viverrines has been selected as the most probable. But for the fact that so many of the bones drawn belong to one individual, I should feel great hesitation in publishing this grotesque figure.

In the following table comparative measurements of *Hyænodon cruentus* and *Canis occidentalis* are given to display the different proportions of the various parts of the skeleton in the two genera. In both cases the length of the skull is taken as 100 and the relative lengths of the different bones calculated to the nearest integer. There is some room for error in the measurements of *Hyænodon*, because the skeleton is made up from several individuals, though the skull, neck, nine thoracic and four lumbar vertebræ, the sacrum, scapula, ulna and radius, carpus, femur, tibia and fibula are all from one specimen. In addition to this it should be noted that the different specimens contain many parts in common, so that the various proportions may be calculated from one to the other without any great risk of serious error. Thus, the small, undetermined *H. sp.* has the skull, vertebral column complete to the sacrum, tibia and fibula and hind-foot; a second specimen of *H. cruentus* consists of the mandible, axis, humerus, ulna, pelvis, femur; a third of the skull, many vertebræ, femur and pes, and so on. The wolf-skeleton has been selected for the purpose of comparison, because the actual length of the skull is not far from being the same as that of *H. cruentus*, and it is therefore well adapted for bringing clearly to light the altogether different proportions of a modern carnivore from those of even a highly differentiated creodont.

It is quite possible that, as Filhol has suggested, *Hyænodon* was of aquatic habits; if so, this would partly account for its extraordinary proportions.

	C. OCCIDENTALIS.	H. CRUENTUS.
Length of skull	100	100
" of neck	97	67
" of thoracic region	139	127
" of lumbar region	93	83
" of scapula	63	53
" of humerus	89	67
" of radius	83	52
" of manus, without phalanges	35	29
" of pelvis	63	65
" of femur	93	72
" of tibia	92	61
" of pes, without phalanges	48	43

VIII. THE RELATIONSHIPS OF HYÆNODON.

It has been customary of late to include *Hyænodon* and *Pterodon* with *Oxyæna* in the same family, a plan which I have followed in my latest paper on the creodonts (No. 7). The propriety of such reference will depend upon the significance which is assigned to the family groups. In the classification of recent animals the family is employed to include all the genera which agree with one another in the possession of certain definite structural characters, and it thus often embraces members of many collateral lines. This principle is useful in grouping the recent forms and gives expression to the relationships of animals existing together at any given period of the earth's history. In the plan of family classification adopted by Osborn and Schlosser, on the other hand, the family represents a single phylogenetic line or branch, which may include short side-branches not leading to permanent modifications. This method is useful to express the relationships obtaining between the various successive faunas which have been discovered. Each of these methods thus possesses certain advantages and each is exposed to the necessity of more or less arbitrarily separating allied genera. Schlosser's method, however, is much better adapted to the needs of palæontological inquiry; indeed, it is almost impossible to use the other with any degree of satisfaction.

Thanks to the researches of Osborn (No. 3) and Wortman (No. 8) the structure of *Oxyæna* and *Patriofelis* is now well understood and a detailed comparison of these genera with *Hyænodon* may be made. As the result of such comparison I have no hesitation in adopting Wortman's suggestion of a return to Cope's original scheme and separating the *Oxyænidæ* from the *Hyænodontidæ*. That these two families are nearly related to each other and were derived from a common stock is clear, but with all their resemblances, they represent diverging lines. In the *Oxyænidæ* the face is much shortened, with a consequent reduction in the number of teeth. This reduction affects the molars principally, the formula being $m\frac{2}{2}$, but in effect $^{\underline{m2}}$ is almost lost, as well; it is very small and forms a transversely directed tubercle, while $^{\underline{m1}}$ is much the largest of all the cheek-teeth. The fourth upper premolar is a well-developed sectorial, with large posterior cutting edge, or tritocone, and in some species with antero-external cusps. In the lower jaw $_{\overline{m1}}$ is large, though somewhat smaller than $_{\overline{m2}}$, which with $^{\underline{m1}}$ forms the principal pair of sectorial teeth, while $_{\overline{m3}}$ has disappeared. In *Patriofelis* the reduction of teeth has proceeded still farther and gives the formula, $p\frac{3}{3}$, $m\frac{1}{2}$, while in both genera there are but two pairs of lower incisors. In the *Hyænodontidæ* the emphasis of development, so to speak, is differently placed, the principal pair of sectorials being $^{\underline{m2}}$ and $_{\overline{m3}}$, which are much the largest teeth in their respective series; a second and less important pair is formed by $^{\underline{m1}}$ and $_{\overline{m2}}$, while $_{\overline{m1}}$ is very greatly reduced in size and smaller than most of the premolars. The last upper premolar is not sectorial in form, the tritocone being but little developed.

Similar divergences appear in the skull. The face in the *Oxyænidæ* is short and abruptly truncated; the zygomatic arches are enormously developed and curve out strongly from the sides of the skull, as well as arching decidedly upward, there being not the least tendency toward the assumption of the peculiar conditions found in *Hyænodon* and, to a much less marked degree, in *Pterodon*. The lachrymal is not expanded on the face (*fide* Wortman) and the mastoid processes are very largely developed. In the *Hyænodontidæ*, on the contrary, the face is not shortened, but rather elongated and tapering; the zygomatic arches are straight, slender and placed very low down on the sides of the skull, while anteriorly they are continued by the alveolar portion of the maxillaries. This unique arrangement has attained only an incipient stage in *Pterodon*. The lachrymal forms a large facial plate in front of the orbit and the mastoid process is rudimentary.

The extremities display divergences of at least equal significance. In the more ancient family the scapula is large, with broad, flattened acromion and largely developed metacromion. The humerus is short and massive, with enormous deltoid and supinator ridges. The ulna is very massive and has a remarkably high olecranon. In *Oxyæna* the carpal bones are of moderate width and of the form usual among the Carnivora, while in *Patriofelis* they have more the width found in *Hyænodon;* mc. II has lost its connection with the magnum. In *Hyænodon* the carpus, especially the cuneiform, has greatly widened and mc. II has an extensive connection with the magnum, while that of mc. III with the unciform is much reduced. Even more important are the differences in the pes.

In the *Oxyænidæ* the astragalus is depressed, flattened and hardly at all grooved; it has a stout neck and the head articulates extensively with the cuboid, the proximal end of which thus receives a highly characteristic shape. The calcaneum has a short tuber and does not articulate with the fibula while the metatarsals have a strongly divergent position, almost like the sticks of a fan. In the *Hyænodontidæ* the pes has become entirely carnivorous in type; the astragalus does not articulate with the cuboid, but the calcaneum has developed a very large and prominent facet for the fibula, such as occurs in no other unguiculate. The metatarsals do not diverge strongly from one another, but pursue an approximately parallel course.

The group to which both the *Oxyænidæ* and *Hyænodontidæ* may be traced back is undoubtedly the family *Proviverridæ*. The skull-structure of such genera as *Cynohyænodon* and *Sinopa* (*Stypolophus*) is of a kind from which that characteristic of the *Oxyænidæ*, on the one hand, and of the *Hyænodontidæ*, on the other, might readily be derived; even the remarkable character of the posterior nares found in the latter is perhaps in an incipient stage. The dentition also is of the type which we should expect to find in the ancestral form; this is particularly seen in the reduced size and transverse direction of m^3, the very close approximation of the para- and metacones on the upper molars and the development of a trenchant posterior ridge behind the latter. This type of molar-structure is already indicated in Puerco times and if this feature alone be regarded, the genera *Deltatherium, Sinopa, Oxyæna, Pterodon, Hyænodon*, form a complete series of transitions from the tritubercular to the exclusively sectorial pattern of crown. Various considerations, however, show that the genera mentioned do not form a phylogenetic series. The lower molars, though still in a very primitive tuberculo-sectorial stage, as well as the premolars, canines and incisors of both jaws in the *Proviverridæ* are of a type which might easily be modified into those of the other two families. *Sinopa* and *Cynohyænodon* present a particular resemblance to the *Hyænodontidæ* in the very small size and early eruption of the first lower molar. What little is known of the skeleton of *Sinopa* favors the same view of its relationship to the other families. The astragalus has a moderate articulation with the cuboid and the calcaneum with the fibula.

So far as is yet known, the *Oxyænidæ* are an American family, the supposed members of it which have been found in France being referred to it with very doubtful propriety. The group must have originated in the interval between the Puerco and Wasatch formations from some Puerco genus not yet identified, but which, in all probability, was but little removed from *Deltatherium*. The *Hyænodontidæ*, on the other hand, arose in the Old World, appearing first in the upper Eocene (or lower Oligocene) and by a later migration reaching North America, where they are not known before the (upper) Oligocene, or White River beds.

Pterodon apparently did not accompany *Hyænodon* in this migration, though it is represented by the very closely allied genus *Hemipsalodon*, which differs only in the character of the talon on m_3. It is a significant fact that this genus has been found only in the Titanotherium-beds of Canada (lat. 49°, 35′ N.) which contain a fauna in several respects different from that of the regions farther south and one which in many ways is more distinctively allied to the Oligocene fauna of Europe. These differences are doubtless owing to climatic and geographical factors rather than to any discrepancy of geological age. Assuming, as we may safely do, that *Hemipsalodon* came from the Old World, the Cypress Hills region would probably represent its southernmost range.

Any attempt to construct a series of genera leading to *Hyænodon* would be premature, though *Proviverra*, or some very similar form, will doubtless prove to be one of the genera through which the line of descent passed.

LIST OF PAPERS QUOTED.

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2. *Leidy, J.*—The Extinct Mammalian Fauna of Dakota and Nebraska. Philadelphia, 1869.
3. *Osborn, H. F.* and *Wortman, J. L.*—Fossil Mammals of the Wahsatch and Wind River Beds Bull. American Museum of Natural History, New York, Vol. IV, 1892.
4. ———— Fossil Mammals of the Lower Miocene White River Beds. Ibid, Vol. II, 1894.
5. *Schlosser, M.*—Die Affen, Lemuren, etc., des europäischen Tertiars. Th. I. Beiträge zur Palæontologie Oesterreich-Ungarns, VI Bd. Vienna, 1887.
6. *Scott, W. B.*—On some new and little known Creodonts. Journ. Acad. Nat. Sci. Phila., Vol. IX, No. 2, 1887.
7. ————A Revision of the North American Creodonta. Proc. Acad. Nat. Sci. Phila., 1892.
8. *Wortman, J. L.*—Osteology of Patriofelis, a Middle Eocene Creodont. Bull. Amer. Mus. Nat. Hist., Vol. VI, 1894.
9. *Zittel, K. v.*—Handbuch der Palæontologie, I Abth., IV Bd. Munich & Leipsic, 1890–1893.

After the foregoing paper on *Ancodus* was completed, the Princeton Museum received an unusually large and fine skull appertaining to this genus from the White River bad lands of South Dakota. The specimen was found in the Metamynodon division of the Oreodon-beds, and appears to represent the same species as that referred by Osborn and Wortman to the *A. americanus* of Leidy. (Bull. Amer. Mus. Nat. Hist., New York, Vol. VI, p. 219.) Leidy's species, however, was found in the Titanotherium-beds, which affords a presumption against its being identical with the specimen before us. As in the skull-fragment described by Osborn and Wortman, the first upper premolar is wanting, an evidence of the constancy of this character. The principal differences from *A. americanus* which may be observed in the dentition are two: (1) P^4 has a much better developed cingulum, especially upon the inner side of the crown. (2) In the upper molars the external buttresses or styles are decidedly less conspicuous, the median buttress (mesostyle) is divided by a deeper cleft and has a tuberculated or crenulated edge.

The differences from *A. brachyrhynchus* are very distinctly marked. (1) $\underline{\text{P1}}$ is absent and the muzzle is much more elongated. (2) The palatal notches are much more deeply incised and extend farther forward. (3) The posterior nares are not displaced so far backward and have a quite different shape, the palatines forming a long and pointed median projection from the anterior border. (4) The size of the animal is greater. Indeed, this skull is distinctly the largest of this genus that has yet been reported from the White River formation.

The mandible has a very shallow, though quite thick, horizontal ramus, with a long and narrow symphysis, the chin expanding into a spatulate shape at the incisive alveolus.

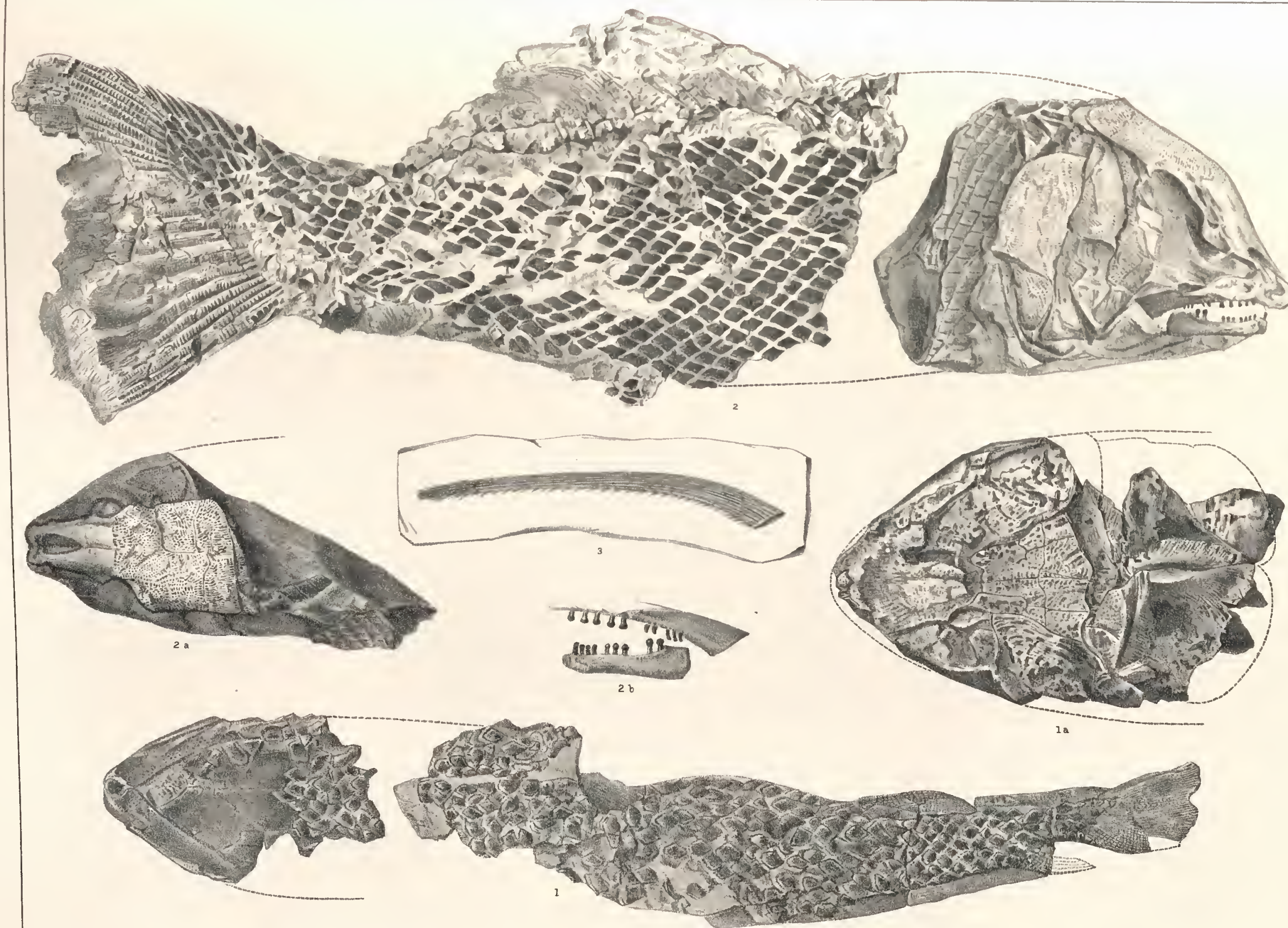
The new species may be called ANCODUS ROSTRATUS; in appearance it approaches most nearly to the European species, *A. velaunus*. It is altogether likely that the large hind-foot, described and figured in the foregoing paper under the name *Ancodus* sp., belongs to *A. rostratus*.

MEASUREMENTS.

Skull, extreme length	0.451	Length of upper molar series	0.071
" length from occipital condyles	.436	Hard palate, length	.300
" " of cranium	.170	Diastema between canine and $\overline{\text{p1}}$	.022
" " of face	.272	" " $\overline{\text{p1}}$ and $\overline{\text{p2}}$	.055
Diastema between canine and $\underline{\text{p2}}$	.090	Length $\overline{\text{p2}}$ to $\overline{\text{m3}}$, inclusive	.132
Length of upper premolar-molar series	.120	" of lower molar series	.082
" " " premolar series	.051	Depth of mandible at $\overline{\text{m3}}$	.040

INDEX TO GENERA, ETC.

1-5 SYMMORIUM RENIFORME 6-7 ORODUS BASALIS.



1. MEGALICHTHYS MACROPOMUS. 2. MACREPISTIUS ARENATUS. 3. LISTRACANTHUS

1-5 STYPTOBASIS 6 DELTODUS 7 MESODON 8-9 URANOPLOSUS 10 COELODUS 11-16 CYPHORNIS

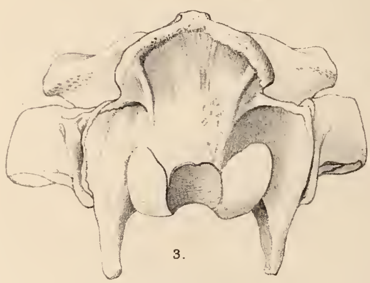
1-13. DINOBASTIS SERUS. 14-16. CANIS INDIANENSIS

1–4. BOS CRAMPIANUS ⅓ · 5–9. BOS SCAPHOCERAS ⅓

1.

2.

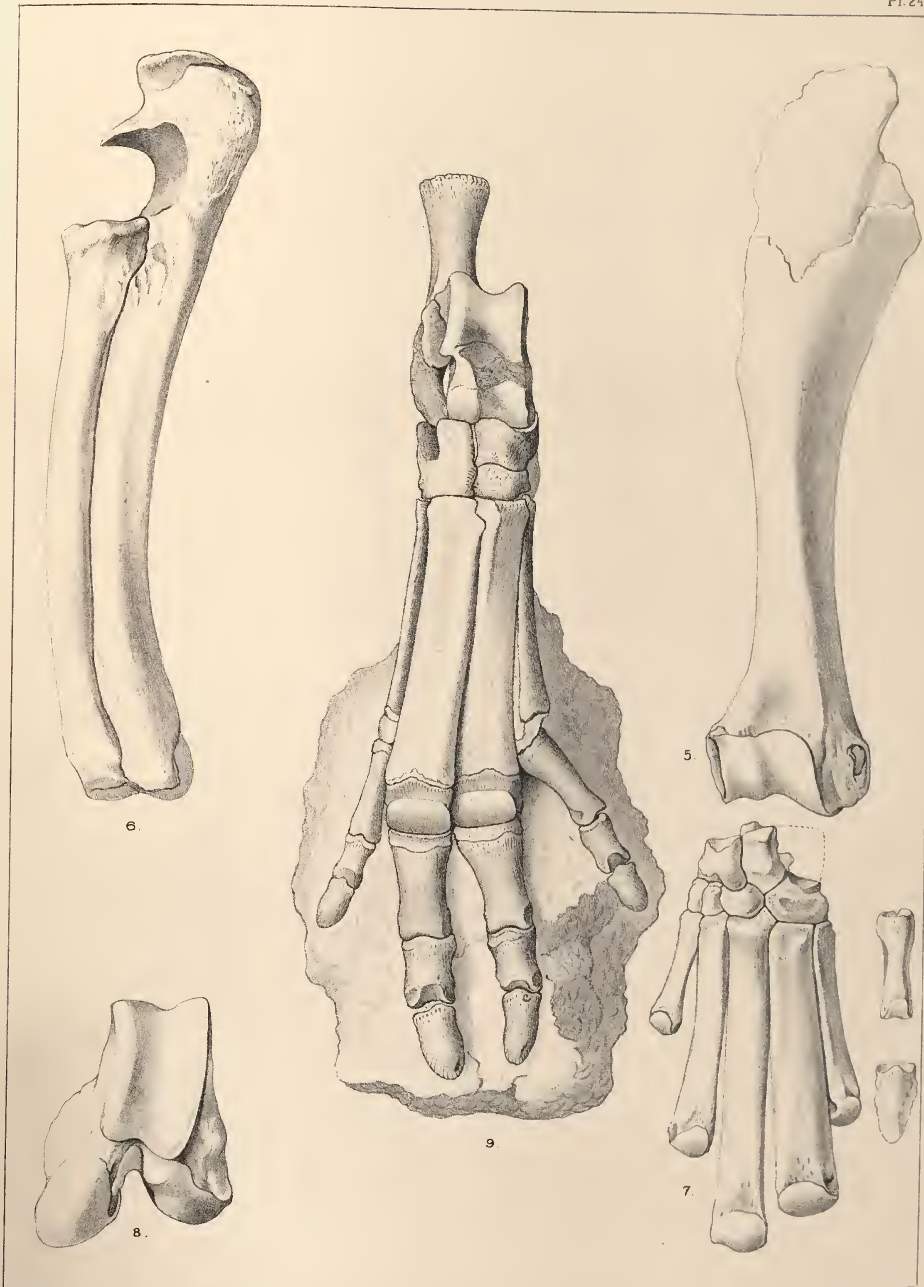
4



3.

R. Weber, del

1 ANCODUS BRACHYRHYNCHUS? 2.3. ANCODUS AMERICANUS ? 4. ANCODUS SP.



5. 6. 7. 8. ANCODUS BRACHYRHYNCHUS? 9. ANCODUS SP.

Hayden Memorial Geological Fund.

Mrs. Emma W. Hayden has given to the Academy of Natural Sciences of Philadelphia in trust the sum of $2,500 to be known as the Hayden Memorial Geological Fund, in commemoration of her husband, the late Prof. Ferdinand V. Hayden, M. D., LL. D. According to the terms of the trust, a bronze medal and the balance of the interest arising from the fund are to be awarded annually for the best publication, exploration, discovery or research in the sciences of geology and paleontology, or in such particular branches thereof as may be designated. The award and all matters connected therewith are to be determined by a committee to be selected in an appropriate manner by the Academy. The recognition is not confined to American naturalists.