













SMITHSONIAN

Miscellaneous Collections

VOLUME XLV

(QUARTERLY ISSUE, VOLUME I)



1457

"EVERY MAN IS A VALUABLE MEMBER OF SOCIETY WHO, BY HIS OBSERVATIONS, RESEARCHES,  
AND EXPERIMENTS, PROCURES KNOWLEDGE FOR MEN"—SMITHSON.

CITY OF WASHINGTON  
PUBLISHED BY THE SMITHSONIAN INSTITUTION

1903

PRESS OF  
THE NEW ERA PRINTING COMPANY  
LANCASTER, PA





v. 45

Dir. Off. - 12 pl.

## ADVERTISEMENT

The present series, entitled SMITHSONIAN MISCELLANEOUS COLLECTIONS, is intended to include all the publications issued directly by the Smithsonian Institution in octavo form, excepting the ANNUAL REPORT; those in quarto constituting the SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE. The quarto series includes memoirs embracing the records of extended original investigations and researches, resulting in what are believed to be new truths and constituting positive additions to the sum of human knowledge. The octavo series is designed to contain reports on the present state of our knowledge of particular branches of science; instructions for collecting and digesting facts and materials for research; lists and synopses of species of the organic and inorganic world; museum catalogues; reports of explorations; aids to bibliographical investigations, etc., generally prepared at the express request of the Institution, and at its expense.

In the CONTRIBUTIONS TO KNOWLEDGE, as well as in the MISCELLANEOUS COLLECTIONS, the actual date of the publication of each article is that given in the Table of Contents, and not necessarily that of the volume in which it appears.

The *Quarterly Issue* of the SMITHSONIAN MISCELLANEOUS COLLECTIONS is designed chiefly to afford a medium for the early publication of the results of researches conducted by the Smithsonian Institution and its bureaus, and especially for the publication of reports of a preliminary nature.

S. P. LANGLEY,  
*Secretary, Smithsonian Institution.*



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# SMITHSONIAN

## MISCELLANEOUS COLLECTIONS

QUARTERLY ISSUE

JULY-SEPTEMBER, 1903

### SEVENTY NEW MALAYAN MAMMALS

BY GERRIT S. MILLER, JR.

Dr. W. L. Abbott has presented to the United States National Museum four large collections of Malayan mammals of which it has been found impracticable to publish detailed accounts. The first was made on the islands of the Mergui Archipelago, off the west coast of Tenasserim, during the winter of 1900-01; it contains about four hundred specimens, and is noteworthy for its richness in slightly differentiated insular forms of rats and squirrels. The second collection, of about two hundred and seventy specimens, forms part of the results of explorations among the islands of the South China Sea not previously visited,<sup>1</sup> and on the neighboring east coast of Johore. Peculiar insular species of porcupine and flying lemur, both from Pulo Aor, may be regarded as the most interesting of the new mammals found during this expedition. The third was obtained in the Rhio Archipelago, off the southern extremity of the Malay Peninsula, in August and September, 1902, and numbers about one hundred and seventy-five specimens. Two of the new mammals which it includes, a monkey and a treeshrew, show an unexpected likeness to species occurring in the Anamba and Natuna Islands. The last and most valuable of the four collections was made with the assistance of Mr. C. B. Kloss during the winter of 1902-03 on the Pagi Islands, the Batu Islands, and Pulo Nias, islands of the chain lying parallel to the west coast of Sumatra.<sup>2</sup> It contains about three hundred specimens, among

<sup>1</sup> For an account of the mammals obtained during Dr. Abbott's first and second cruise in the South China Sea, see Miller, *Proc. Washington Acad. Sci.*, II, pp. 203-246, August 20, 1900, and III, pp. 111-138, March 26, 1901.

<sup>2</sup> For an account of the mammals obtained by Dr. Abbott on the more northerly islands of this archipelago, see Miller, *Proc. U. S. Nat. Mus.*, XXVI, pp. 437-484, February 3, 1902.

which are represented more than thirty hitherto undescribed species. Five of these are monkeys, two of which, a dwarf siamang and a member of a new genus *Simias*, differ from their known relatives by very remarkable characters. Study of these collections has led to the reexamination of much of Dr. Abbott's material that has been previously reported on. The seventy new mammals here described have been found in the course of this work.

**TRAGULUS BATUANUS** sp. nov.

*Type*.—Adult female (skin and skull), No. 121,697, United States National Museum. Collected on Tana Bala, Batu Islands, Sumatra, February 5, 1903, by Dr. W. L. Abbott. Original number, 2226.

*Characters*.—A large member of the *Tragulus napu* group with wholly black neck and black throat stripes. The black of neck extends forward over face and cheeks more than in any other species except *Tragulus annæ*, *T. jugularis*, and *T. bunguranensis*. From all of these the Batu animal is distinguished by the normal pattern of the throat markings.

*Color*.—Type: back ochraceous heavily shaded by the black hair-tips, neither color distinctly in excess of the other. On sides the ochraceous fades to buff and the black shading becomes slightly less heavy than on back. Muzzle, loral stripe, face, except dull ochraceous line 4 mm. wide bordering loral stripe, crown, ears, entire neck to outer white throat stripes, and cheeks to level of posterior canthus of eye, glossy black. Cheek from muzzle to posterior canthus of eye dull grizzled ochraceous. On close inspection dull ochraceous annulations may be detected on the black portion of the cheeks and on the neck, particularly at sides. These are nowhere sufficiently numerous to break the clear black effect, except at front of shoulders, where they rapidly increase in number, producing a rather abrupt transition to the color of the back. Underparts and light throat stripes white. A brownish stripe 60 mm. long and 4 mm. wide on middle of chest. Dark throat stripes clear black; collar black, noticeably speckled with dull ochraceous. The throat pattern is in every way normal, though the black stripes are perhaps narrower than usual. At anterior termination these stripes are about 10 mm. apart, and there is no brown wash on the white in front of them. Legs like back externally, the inner surface white. On hind legs the white disappears at about middle of tarsus; below this point the legs and feet are sprinkled with dull ochraceous hairs. Tail like back above, but ochraceous not as bright, white below and at tip.

*Skull and teeth.*—The skull is very large and the nasals are unusually long, but otherwise I do not detect any tangible cranial characters. Teeth large, particularly the upper premolars.

*Measurements.*—External measurements of type: total length, 680; head and body, 595; tail vertebræ, 85; hind foot, 145 (130); ear from meatus, 36.6; ear from crown, 30; width of ear, 24.

Cranial measurements of type: greatest length, 120 (116);<sup>1</sup> basal length, 112 (108); basilar length, 105 (102); occipito-nasal length, 110 (105); length of nasals, 40 (36); greatest breadth of both nasals together, 13 (13); diastema, 15 (12.4); zygomatic breadth, 54 (48); least interorbital breadth, 32 (30.4); mandible, 95 (91); maxillary toothrow (alveoli), 41 (39); maxillary premolars (crowns), 22 (20.4); mandibular toothrow (alveoli), 47 (45); mandibular premolars (crowns), 23.4 (20).

*Specimens examined.*—Four, all from the Batu Islands, one from Tana Masa, the rest from Tana Bala.

*Remarks.*—Unfortunately the type is the only adult in the collection. The immature individuals differ from it in the presence of a grayish buff wash on middle of belly, a character which is probably individual rather than due to the difference in age. The species is easily recognizable by the forward extension of the black neck area, combined with the normal throat pattern.

#### TRAGULUS RUSSULUS sp. nov.

*Type.*—Adult male (skin and skull), No. 121,701, United States National Museum. Collected on Tana Bala, Batu Islands, Sumatra, February 8, 1903, by Dr. W. L. Abbott. Original number, 2249.

*Characters.*—A member of the *kanchil* group similar to *Tragulus russeus* of the Banjak Islands, but upper parts not as dark, belly with less extensive yellowish suffusion, and throat pattern always normal. Skull and teeth not so large as in *Tragulus russeus*.

*Color.*—Type: general color above orange-ochraceous darker than that of Ridgway, the neck and outer surface of limbs brighter than body. The hairs of the back are tipped with black, forming a slight, uniform, dark clouding, much less pronounced than in *Tragulus russeus*. On shoulders this shading deepens abruptly into the black, slightly grizzled neck stripe. Crown a grizzle of dusky brown and buff. Cheeks dull buff. A faintly indicated buffy stripe borders upper margin of very ill-defined dark loreal stripe. Ears blackish. <sup>4</sup>Throat pattern normal, the dark stripes and collar orange-

<sup>1</sup> Measurements in parenthesis are those of an adult female paratype (No. 113,120) of *Tragulus nigricollis*.

ochraceous, the latter clear, the former slightly grizzled by dark brown hair-tips. The dark stripes meet anteriorly. From collar a dull orange-ochraceous stripe about 5 mm. in width extends back over middle of chest to join the pale orange-buff area 80 mm. long by 40 mm. wide which occupies middle of belly. With these exceptions the entire under surface of body is white. Tail white below and at tip, like back above but not as bright, and much less grizzled.

*Skull and teeth.*—The skull and teeth closely resemble those of *Tragulus russeus* but are not as large.

*Measurements.*—External measurements of type: total length, 535; head and body, 470; tail vertebræ, 65; hind foot, 122 (109); ear from meatus, 32; ear from head, 20; width of ear, 18. External measurements of adult female from the type locality (No. 121,697): total length 550; head and body, 485; tail vertebræ, 65; hind foot, 109 (98).

Cranial measurements of type: greatest length, 98; basal length, 92; basilar length, 86; occipito-nasal length, 87; length of nasals, 31.4; greatest breadth of both nasals together, 15; diastema, 8.8; zygomatic breadth, 44; least interorbital breadth, 28; mandible, 79; maxillary toothrow (alveoli), 33.6; maxillary premolars (crowns), 16.8; mandibular toothrow (alveoli), 37.6; mandibular premolars (crowns), 16.

*Specimens examined.*—Nine, all from the Batu Islands, 6 from Tana Bala, 1 from Tana Masa, and 2 from Pulo Pinie.

*Remarks.*—The orange-buff wash on the belly is occasionally more extensive than in the type, but never conspicuously so. The throat pattern is invariably normal, and the dark stripes always come together anteriorly. In the two skins from Pulo Pinie the general color of the back, sides, and neck is lighter and more buff than in those from the other islands.

#### RATUFA INSIGNIS sp. nov.

*Type.*—Adult male (skin and skull), No. 115,531, United States National Museum. Collected on Pulo Sugi, Rhio Archipelago, August 26, 1902, by Dr. W. L. Abbott. Original number, 1960.

*Characters.*—Externally similar to *Ratufa notabilis* Miller<sup>1</sup> of Linga Island, but size not as great. Skull noticeably smaller than that of *R. notabilis*, and front root of zygoma less abruptly flaring.

*Color.*—The color so closely resembles that of *Ratufa notabilis* as to need no detailed description. In the type the upperparts are

<sup>1</sup> *Proc. Acad. Nat. Sci. Philadelphia*, 1902, p. 150, June 11, 1902.

burnt-umber slightly darker than in the type of *R. notabilis*. Along middle of back there is a faint drab gloss, and the light annulations of the hairs are smaller and more sharply defined than in the related species. Back without the sprinkling of whitish hairs present in the type of *notabilis*. Underparts and inner surface of limbs cream-buff, tinged with brownish yellow, particularly on front legs. The cream-buff area on the legs is narrower than in the type of *Ratufa notabilis*. The pale area of underparts and legs is everywhere separated from the dark adjoining regions by a distinct edging of light tawny-ochraceous. This is present in the type of *R. notabilis*, but much less distinct. In both species the pale flank spot is indicated by an interruption of this edging. Cheeks, feet, and muzzle whitish. Tail concolor with back above, at sides, and tip, dull whitish gray along middle beneath. The four specimens are very uniform in color characters except for the usual effects of bleaching, which are noticeable in two of the skins.

*Skull and teeth*.—The skull and teeth are readily distinguishable from those of *Ratufa notabilis* by their smaller size. The general form of the skull is throughout less broad and robust than in the related species, but this difference is most noticeable in the region of the anterior zygomatic roots, which flare much less abruptly and widely than in the larger animal.

*Measurements*.—External measurements of type: total length, 780; head and body, 360; tail vertebræ, 420; hind foot, 76 (70); ear from meatus, 26.6; ear from crown, 16.

Cranial measurements of type: greatest length, 64.4 (68);<sup>1</sup> basal length, 55 (58); basilar length, 51.4 (55); length of nasals, 21.4 (22); diastema, 15 (14.6); least interorbital breadth, 25.4 (27.4); breadth of braincase above roots of zygomatics, 28 (29.4); zygomatic breadth, 39 (44); mandible, 41 (45); maxillary toothrow (alveoli), 12 (13); mandibular toothrow (alveoli), 12.6 (15).

*Specimens examined*.—Four, all from the type locality.

#### RATUFA CONSPICUA sp. nov.

*Type*.—Adult male (skin and skull), No. 115,528, United States National Museum. Collected on Pulo Bintang, Rhio Archipelago, August 19, 1902, by Dr. W. L. Abbott. Original number, 1900.

*Characters*.—In general similar to *Ratufa notabilis* and *R. insignis*, but skull not so large as in either of these, and pale color of underparts abruptly contrasted with dark brown of sides.

<sup>1</sup> Measurements in parenthesis are those of the type of *Ratufa notabilis*, a young adult male.

*Color*.—Upperparts of type exactly as in *Ratufa insignis* except that the neck and shoulders are more conspicuously speckled by the light annulations of the hairs. Underparts and inner surface of legs cream-buff not tinged with yellow. This color is everywhere sharply defined against the brown. There is a faint trace of the tawny edging between the two colors on hind legs, but to a much less extent than in either of the other species.

The skins show practically no variation in color beyond that due to bleaching.

*Skull and teeth*.—In form the skull is similar to that of *Ratufa insignis*, but in size it is not as large. Teeth as in the related species.

*Measurements*.—External measurements of type: total length, 705; head and body, 330; tail vertebræ, 375; hind foot, 77 (72); ear from meatus, 25.6; ear from crown, 13.

Cranial measurements of type: greatest length, 63; basal length, 54; basilar length, 50; length of nasals, 20.4; diastema, 14; least interorbital breadth, 24; breadth of braincase above roots of zygomata, 27.4; zygomatic breadth, 39; mandible, 38.8; maxillary toothrow (alveoli), 12.8; mandibular toothrow (alveoli), 12.8.

*Specimens examined*.—Seven, all from Pulo Bintang.

#### RATUFA BALÆ sp. nov.

*Type*.—Adult male (skin and skull), No. 121,715, United States National Museum. Collected on Tana Bala, Batu Islands, Sumatra, February 5, 1903, by Dr. W. L. Abbott. Original number, 2224.

*Characters*.—Similar to *Ratufa femoralis* but much darker; back darker than belly; tail blackish. Crown and forehead not noticeably lighter than back. Femoral spot large and conspicuous.

*Color*.—Type: upperparts wood-brown faintly washed with vandyke-brown along middle of back, and showing strong drab reflections in certain lights. On sides the brown brightens to a brownish buff and the shorter hairs show distinct light annulations. The speckling thus produced is inconspicuous. Crown and forehead like sides but not quite as dark. Cheeks slightly tinged with gray. Ears and indistinct eye ring blackish. Whiskers black, their bases surrounded by a whitish patch. Outer surface of legs like sides but strongly tinged with ochraceous-rufous. This is particularly noticeable on front legs between shoulder and wrist, where a clear band is formed between colors of outer and inner surfaces. Feet blackish. Underparts and inner surface of legs clear orange-buff, darker along median line, paler in axillary region. Chin dark grayish. Femoral spot whitish, large and well defined. Entire tail



very dark, blackish vandyke-brown, the hairs fading to a light drabby buff below middle. This color appears faintly at surface along under side, but scarcely more than enough to throw the dark median line of short hairs into contrast.

*Skull and teeth.*—The skull is slightly larger than that of *Ratufa femoralis*, the interpterygoid space is wider and the nasal bones and audital bullæ are longer. Teeth as in the related species.

*Measurements.*—External measurements of type: total length, 725; head and body, 340; tail vertebræ, 385; hind foot, 74 (70).

Cranial measurements of type: greatest length, 65; basal length, 54; basilar length, 50; length of nasals, 21; greatest breadth of both nasals together, 12; least interorbital breadth, 26; zygomatic breadth, 38; mandible, 39.6; maxillary toothrow (alveoli), 12.8; mandibular toothrow (alveoli), 13.6.

*Specimens examined.*—Eight, all from Tana Bala.

*Remarks.*—This squirrel is readily distinguishable from all other known members of the genus except those occurring on Tana Masa and Pulo Pinie by its rich coloration, blackish tail, and conspicuous femoral spot. The tail is nearly as dark as that of *Ratufa nigrescens*, but in the Mansalar animal the back also is blackish, and the femoral spot is obsolete. In *Ratufa femoralis* the back is distinctly lighter than the belly, while the opposite is true of the Batu species.

#### RATUFA MASÆ sp. nov.

*Type.*—Adult male (skin and skull), No. 121,818, United States National Museum. Collected on Tana Masa, Batu Islands, February 21, 1903, by Dr. W. L. Abbott. Original number, 2330.

*Characters.*—Like *Ratufa balæ*, but entire head grayish, in distinct contrast with back. Femoral spot large and well defined.

*Color.*—The color so closely resembles that of *Ratufa balæ* that no detailed account is required. The whole crown and forehead, however, are a grizzled yellowish gray, noticeably lighter than rest of upperparts. In the grizzled area the hairs are slaty at base, then yellowish brown, followed by a conspicuous whitish cream-buff annulation and a dark tip. Cheeks clear grizzled gray, the general effect between the hair-brown and smoke-gray of Ridgway, the same color extending as a broad band across throat and chin. Femoral spot large and conspicuous, whitish cream-buff.

*Measurements.*—Measurements of type: total length, 730; head and body, 340; tail vertebræ, 390; hind foot, 72 (69); skull, greatest length, 62; basal length, 52; length of nasals, 20; interorbital constriction, 25; zygomatic breadth, 39.

*Specimens examined.*—Four, all from Tana Masa.

**RATUFA PINIENSIS** sp. nov.

*Type*.—Adult male (skin and skull), No. 121,840, United States National Museum. Collected on Pulo Pinie, Batu Islands, March 1, 1903, by Dr. W. L. Abbott. Original number, 2343.

*Characters*.—Like *Ratufa masæ* but darker throughout, particularly on the ventral surface. Head grayish in strong contrast with back. Femoral spot less well developed than in the two related forms.

*Color*.—In general the color is like that of the two other Batu members of the group, but the vandyke-brown wash on the back is heavier, particularly in lumbar region, and the underparts are darkened nearly to ochraceous-rufous. The inguinal and axillary regions are not as dark as the rest of the ventral surface. Crown even lighter and clearer gray than in *Ratufa masæ*, scarcely yellower than cheeks. Femoral spot not as large as in the related forms, and so heavily grizzled by dark yellowish brown annulations as to be less conspicuous than in any of the Sumatran members of the group except *Ratufa nigrescens*.

*Skull and teeth*.—The skull and teeth do not differ tangibly from those of *Ratufa balæ*.

*Measurements*.—Measurements of type: head and body, 325; tail imperfect; hind foot, 73 (69); skull, greatest length, 62; basal length, 52; basilar length, 48.4; length of nasals, 11; greatest breadth of both nasals together, 12; least interorbital breadth, 26; zygomatic breadth, 38; mandible, 39; maxillary tooththrow (alveoli), 12; mandibular tooththrow (alveoli), 13.

*Specimens examined*.—Six, all from Pulo Pinie.

**SCIURUS BILIMITATUS** sp. nov.

*Type*.—Adult female (skin and skull), No. 105,072, United States National Museum. Collected at Tanjong Laboha, Tringanu, Malay Peninsula, September 29, 1900, by C. B. Kloss. Original number (Dr. W. L. Abbott), 671.

*Characters*.—Similar to the Javan *Sciurus nigrovittatus* Horsfield, but tail longer, back more distinctly grizzled, gray of underparts paler, and outer lateral stripe conspicuous and sharply defined.

*Color*.—Upperparts a fine grizzle of black and cream-buff, the latter rather in excess, and brightening to buff on shoulders, neck, and flanks. Cheeks, muzzle, chin, and throat buff, brighter and more rusty than that of Ridgway. Chest, belly, and inner surface of legs pale smoke-gray, the darker bases of the hairs appearing

irregularly at surface. Lateral stripes clear and sharply defined, the inner black, the outer buff. The width of each at middle is about 10 mm.

*Measurements*.—Measurements of type: total length, 485; head and body, 205; tail vertebrae, 180; hind foot, 46 (43).

*Specimens examined*.—Malay Peninsula; Tanjong Laboha, Tringanu, 1; no exact locality, 1; Tioman Island, 12.

*Remarks*.—As compared with a series of five skins of *Sciurus nigrovittatus* from western Java the characters of *Sciurus bilimitatus* are both pronounced and constant. There is no variation worthy of note, and the specimens from Tioman Island appear to agree in all respects with those from the mainland. In *Sciurus nigrovittatus* the pale lateral stripe is so ill defined that in some skins it would easily pass unnoticed. Horsfield, in fact, does not mention it.

#### SCIURUS PEMANGILENSIS sp. nov.

*Type*.—Adult female (skin and skull), No. 112,460, United States National Museum. Collected on Pulo Pemangil, off coast of Johore, June 12, 1901, by Dr. W. L. Abbott. Original number, 1062.

*Characters*.—A pallid member of the *Sciurus vittatus* group somewhat resembling *Sciurus lautensis* of the North Natuna Islands, but smaller and with upperparts a clearer, less yellowish gray.

*Color*.—Upperparts a fine inconspicuous grizzle of black and pale very dull buff (or light wood-brown), the two colors about evenly mixed on back, the buff slightly in excess on sides, the general effect throughout very near broccoli-brown. Cheeks and outer surface of legs light wood-brown. Entire upper surface of tail like back, but more coarsely grizzled. Under surface of tail nearly clear, pale, wood-brown (or cream-buff with a slight brownish tinge) except at edges and at tip, where it is grizzled. Underparts and inner surface of legs bright ochraceous-buff (considerably more yellow than that of Ridgway), fading to pale wood-brown on chin. Outer lateral stripe buffy white, well defined and about 7 mm. in width. Inner lateral stripe diffuse, about 10 mm. in breadth, its color like that of sides of body but slightly darker and overlaid by a thin wash of ochraceous-buff. Feet dull buffy gray, not noticeably paler than legs.

*Skull and teeth*.—The skull and teeth resemble those of *Sciurus lautensis* except that the rostrum appears to be somewhat broader and more robust.

*Measurements*.—Measurements of type: total length, 335; head and body, 185; tail vertebrae, 150; hind foot, 44 (41); skull, greatest length, 49; zygomatic breadth, 28.

*Specimens examined*.—Twelve, all from Pulo Pemangil.

*Remarks*.—Among the squirrels of the *Sciurus vittatus* group with which I am familiar this species is readily distinguishable by its uniform gray dorsal surface, in which the grizzle has become obsolete.

**SCIURUS AORIS** sp. nov.

*Type*.—Adult female (skin and skull), No. 112,418, United States National Museum. Collected on Pulo Aor, off coast of Johore, June 5, 1901, by Dr. W. L. Abbott. Original number, 1002.

*Characters*.—A pallid member of the *Sciurus vittatus* group, much like *S. pemangilensis* in general color, but back and sides sharply and distinctly grizzled, and red of underparts slightly less bright.

*Color*.—Type: The type so closely resembles that of *Sciurus pemangilensis* that no detailed description is necessary. On back and sides the elements of the grizzle are essentially the same in the two species, but in that from Pulo Aor the colors are so sharply contrasted as to produce the finely speckled appearance characteristic of most of the members of the group. Underparts essentially as in *S. pemangilensis* but the red not as bright.

*Skull and teeth*.—I can detect nothing to distinguish the skull and teeth from those of *Sciurus pemangilensis*.

*Measurements*.—Measurements of type: total length, 335; head and body, 185; tail vertebrae, 150; hind foot, 44 (41); skull, greatest length, 45; zygomatic breadth, 25.

*Specimens examined*.—Fifteen, all from Pulo Aor.

*Remarks*.—*Sciurus aoris* is readily distinguishable from *S. pemangilensis*, by its sharply speckled back. In general color it closely resembles *Sciurus lautensis*, but the flanks and thighs are uniform with the back and not tinged with fulvous as in the Natuna animal. The series shows no marked variations in color.

**SCIURUS PENINSULARIS** sp. nov.

*Type*.—Adult male (skin and skull), No. 112,511, United States National Museum. Collected on north bank of Endau River, Pahang, June 21, 1901, by Dr. W. L. Abbott. Original number, 1078.

*Characters*.—Like *Sciurus vittatus*, but red of underparts strongly tinged with ochraceous, and cheeks scarcely more yellow than sides of neck.

*Color*.—Type: upperparts and tail a fine grizzle of black and ochraceous-buff, the latter a little in excess on body, the former on tail. Underparts and inner surface of legs tawny, washed, particu-

larly on chest, with ochraceous. Lateral stripes as in *Sciurus vittatus*, the outer whitish cream-buff, about 6 mm. wide at middle, the inner black and about 10 mm. in width. Cheeks like back, but with a light wash of ochraceous-buff, this wash not distinct enough to produce a marked contrast with color of neck.

*Measurements.*—Measurements of type: total length, 390; head and body, 210; tail vertebræ, 180; hind foot, 50 (47); skull, greatest length, 49.4; zygomatic breadth, 28.

*Specimens examined.*—Nine, five from the banks of the Endau River, and four from Singapore.

*Remarks.*—The squirrel of the *vittatus* group inhabiting the southern end of the Malay Peninsula is distinguishable from the typical Sumatran animal by its more yellowish underparts and less yellowish cheeks. In true *Sciurus vittatus*, as represented by specimens from Tapanuli Bay, the red area of the body is very nearly the same as the orange rufous of Ridgway, and the cheeks are so heavily washed with buff as to contrast strongly with sides of neck.

#### SCIURUS PANNOVIANUS sp. nov.

*Type.*—Adult male (skin and skull), No. 112,351, United States National Museum. Collected on Pulo Pannow, Atas Islands, South China Sea, May 28, 1901, by Dr. W. L. Abbott. Original number, 952.

*Characters.*—Like *Sciurus peninsularis*, but size less, dark lateral stripes much broader and more diffuse, and tail with fairly well defined black pencil.

*Color.*—Type: The general color so closely resembles that of the type of *Sciurus peninsularis* as to need no detailed description. The dark lateral stripes are less sharply outlined than in the mainland animal, however, and their width at middle is at least 15 mm. Tail with blackish pencil distinctly visible both above and below.

*Skull and teeth.*—The skull and teeth are not so large as in *Sciurus peninsularis*, and the audital bullæ are smaller and less inflated, particularly in their posterior segment.

*Measurements.*—Measurements of type: total length, 380; head and body, 193; tail vertebræ, 185; hind foot, 48 (45); skull, greatest length, 47; zygomatic breadth, 26.4.

*Specimens examined.*—Ten, all from Pulo Pannow.

*Remarks.*—From *Sciurus abbottii* and *S. anambensis* the Pannow squirrel is distinguished by its darker upperparts, brighter under surface, and black-tipped tail. The series of ten specimens shows no color variations worthy of note.

## SCIURUS ICTERICUS sp. nov.

*Type*.—Adult female (skin and skull), No. 121,727, United States National Museum. Collected on Tana Bala, Batu Islands, February 4, 1903, by Dr. W. L. Abbott. Original number, 2223.

*Characters*.—In general appearance like *Sciurus vittatus*, but size greater, color above darker, lateral stripes less distinct, and cheeks bright, clear, yellowish buff.

*Color*.—Type: upperparts and outer surface of legs a uniform fine grizzle of black and buff, the former everywhere in excess. Underparts and inner surface of legs rufous. Cheeks clear buff-yellow in striking contrast with surrounding parts. This color extends from base of whiskers to level of anterior margin of ear, and is continuous with the clear buff-yellow eye ring. This ring is 3 mm. wide over middle of eye. Posteriorly the buff area extends upward onto basal half of ear, but in this region it becomes dull and grizzled. Behind mouth and chin it becomes mixed with the rufous of underparts. The lips and chin are, however, dark grizzled gray. Outer surface of ears blackish. Feet like legs, but tinged with gray. Pale lateral stripe dull, light smoke-gray, only 5 mm. wide at middle and reduced in extent at each end. Dark stripe blackish, about 7 mm. wide, slightly longer than pale stripe. Tail like back, but more coarsely grizzled, and light bands on hairs less yellow; pencil indistinctly blackish.

*Skull and teeth*.—The skull is similar to that of *Sciurus vittatus* but is much larger and the audital bullæ are broader and less elevated. Teeth similar to those of *Sciurus vittatus* but larger throughout.

*Measurements*.—Measurements of type: total length, 420; head and body, 225; tail vertebræ, 195; hind foot, 49 (46); skull, greatest length, 54 (51);<sup>1</sup> basal length, 46.6 (43.6); zygomatic breadth, 32.6 (30); least interorbital breadth, 20 (18); mandible, 34 (32); maxillary toothrow (alveoli), 10.2 (9.6).

*Specimens examined*.—Nine, from the following of the Batu Islands: Pulo Pinie, 1; Tana Bala, 7; Tana Masa, 1.

*Remarks*.—This strikingly characterized squirrel needs no special comparison with any of the members of the group to which it belongs. The specimens show no variation worthy of note except that the skin from Pulo Pinie has the light element in the tail less yellow than the others.

<sup>1</sup> Cranial measurements in parenthesis are those of an adult female *Sciurus vittatus* from Tapanuli Bay, Sumatra (No. 114,518).

**SCIURUS ATRATUS** sp. nov.

*Type*.—Adult female (skin and skull), No. 121,524, United States National Museum. Collected on North Pagi Island, Sumatra, November 22, 1902, by Dr. W. L. Abbott. Original number, 2087.

*Characters*.—A large member of the *Sciurus vittatus* group with clear black tail, blackish brown upperparts, and blackish gray belly. Lateral stripes nearly lost in the general darkening of the fur.

*Color*.—Type: upperparts and outer surface of hind legs an ill-defined grizzle of black and dull russet, the former everywhere much in excess, but particularly so on middle of posterior half of back, where the lighter color is scarcely noticeable except on close inspection. Outer surface of front legs black. Cheeks dull black. Feet and ears blackish hair-brown. Tail clear black throughout, the hairs with no indication of lighter bands except at extreme base of tail, and even here very inconspicuously. Underparts and inner surface of legs a mixture of black and smoke-gray, each hair wholly of one color or the other. The gray is slightly in excess on throat and front legs, the black on chin, chest, belly, and hind legs. Black lateral stripe about 10 mm. broad. While it extends from front leg to middle of thigh it is not noticeable at first sight, on account of its slight contrast with the surrounding parts. Pale lateral stripe dull russet, more reddish than that of Ridgway, about 10 mm. wide, but so ill defined and inconspicuous that it might readily pass unobserved. Throughout the body the hairs are unusually glossy, and along median line from crown to middle of back there is a faint sprinkling of entirely white hairs.

*Skull and teeth*.—The skull and teeth closely resemble those of *Sciurus ictericus*, but the braincase is less highly arched and the nasals are broader in proportion to their length.

*Measurements*.—Measurements of type: total length, 395; head and body, 230; tail vertebrae, 165; hind foot, 49 (46); skull, greatest length, 54; basal length, 46; zygomatic breadth, 32; least interorbital breadth, 18; mandible, 35; maxillary toothrow (alveoli), 10.

*Specimens examined*.—Twenty-one, from the following localities: North Pagi Island, 8; South Pagi Island, 13.

*Remarks*.—While the characters as a whole are very constant there are certain rather considerable variations. In most of the skins the gray hairs are in excess of the black on entire ventral surface, but in one (No. 121,613) the opposite is conspicuously the case. The whitish hairs on the dorsal surface are sometimes concentrated on head and neck so as to give this region a noticeably grayish cast.

The tail is invariably clear black, except at extreme base, a character which will serve to distinguish the animal from the Siporan *Sciurus melanogaster* at a glance, though the two species are of about the same color and size.

**SCIURUS PINIENSIS** sp. nov.

*Type*.—Adult female (skin and skull), No. 121,800, United States National Museum. Collected on Pulo Pinie, Batu Islands, Sumatra, March 1, 1903, by Dr. W. L. Abbott. Original number, 2344.

*Characters*.—In general appearance like *Sciurus natunensis* (Thomas), but size less, and skull with short, broad rostrum much as in *Sciurus tenuis*.

*Color*.—Upperparts a fine grizzle of black and dull light ochraceous, the latter everywhere a little in excess, but more particularly so on sides. Crown, feet, and outer surface of legs like back, but darker and more finely grizzled. Cheeks, eye ring, and ill-defined area about roots of whiskers nearly clear ochraceous. A wash of the same color on anterior inner surface of thigh. Underparts and inner surface of legs cream-buff, lighter than that of Ridgway anteriorly and on front legs, darkening posteriorly and on hind legs almost to buff. The light and dark areas of front leg are separated on outer side by an almost clear blackish line. Tail like back, but darker above and lighter below, everywhere more coarsely grizzled; pencil black.

*Skull and teeth*.—Skull smaller than that of *Sciurus natunensis* and without elongation of muzzle. In size and general form it closely resembles the skull of *Sciurus tenuis*, but is not as broad interorbitally, the audital bullæ are smaller, and the nasal bones are shorter. Teeth as in *Sciurus tenuis* and *S. natunensis* but much smaller.

*Measurements*.—External measurements of type: total length, 210; head and body, 134; tail vertebræ, 75; hind foot, 32 (29); ear from meatus, 12.6; ear from crown, 7; width of ear, 10; skull, greatest length, 35; basal length, 29.4; length of nasals, 9.4; zygomatic breadth, 20.4; interorbital breadth, 11.2; maxillary tooththrow (alveoli), 5.6.

*Specimens examined*.—One, the type.

**SCIURUS BALÆ** sp. nov.

*Type*.—Adult male (skin and skull), No. 121,799, United States National Museum. Collected on Tana Bala, Batu Islands, February 12, 1903, by Dr. W. L. Abbott. Original number, 2282.



*Characters*.—Similar to *Sciurus pinicensis* but slightly larger, and underparts almost white.

*Color*.—The color throughout is as in *Sciurus pinicensis* except that the light element of the grizzle on upperparts is paler (very nearly the buff of Ridgway), the dark line on outer side of front leg is less developed, and the underparts are nearly white anteriorly, very pale cream-buff posteriorly.

*Skull and teeth*.—The skull is slightly larger than that of *Sciurus pinicensis* and the teeth are relatively smaller, but otherwise I can detect no differences.

*Measurements*.—External measurements of type: head and body, 137; tail, — (broken); hind foot, 34 (31); ear from meatus, 13; ear from crown, 8.6; width of ear, 11; skull, greatest length, 36.6; basal length, 31; length of nasals, 10; zygomatic breadth, 22; inter-orbital breadth, 12.2; maxillary toothrow (alveoli), 5.6.

*Specimens examined*.—One, the type.

*Remarks*.—While this squirrel is very closely related to *Sciurus pinicensis* the characters shown by the single specimen are such that it is impossible to regard the animals from the two islands as identical.

#### SCIURUS PUMILUS sp. nov.

*Type*.—Adult female (skin and skull), No. 121,627, United States National Museum. Collected on South Pagi Island, Sumatra, November 27, 1902, by Dr. W. L. Abbott. Original number, 2098.

*Characters*.—Similar to *Sciurus tenuis* but much smaller and somewhat darker. Not as small as *Sciurus fraterculus*.

*Color*.—Type: back, sides, neck, head, and outer surface of legs a fine, uniform grizzle of black and buff, the latter everywhere a little in excess, but slightly more so on sides than elsewhere. Underparts and inner surface of legs cream-buff, dulled by the appearance at surface of the slaty underfur, this especially noticeable toward sides. Tail like back but more coarsely grizzled and slightly yellower. Feet dull buffy gray, not strongly contrasted with legs.

*Skull and teeth*.—The skull resembles that of the members of the *Sciurus tenuis* group, but is smaller than that of any hitherto known, *S. fraterculus* excepted. As compared with that of *Sciurus procerus*, the smallest that I have at hand, it is decidedly narrower and more elongate in general outline, and the zygomata are less abruptly flaring in front. Teeth relatively as well as actually smaller than those of *Sciurus procerus*.

*Measurements*.—External measurements of type: total length, 205; head and body, 125; tail vertebræ, 80; hind foot, 30 (28); ear from meatus, 11; ear from crown, 7; width of ear, 10.

Cranial measurements of type: greatest length, 34.6; basal length, 28.4 (28);<sup>1</sup> basilar length, 26.8; diastema, 8.4 (8); length of nasals, 10 (9.8); greatest breadth of both nasals together, 5 (5.3); interorbital breadth, 11.8 (12); zygomatic breadth, 19.6 (20.3); mandible, 21; maxillary toothrow (alveoli), 5.8; mandibular toothrow (alveoli), 6.

*Specimens examined*.—Six, all from the Pagi Islands.

*Remarks*.—Although closely related to the *Sciurus fraterculus* of Sipora Island, this squirrel is distinguishable by its less dwarf size and by the absence of rufous tints on sides and upperparts.

#### SCIURUS LANCAVENSIS sp. nov.

1900. *Sciurus concolor* MILLER, Proc. Biol. Soc. Washington, XIII, p. 191, December 21, 1900. Part, specimens from Pulo Lankawi. Not *S. concolor* BLYTH.

*Type*.—Adult male (skin and skull), No. 104,390, United States National Museum. Collected on Pulo Lankawi, off west coast of Malay Peninsula (about 75 miles north of Penang), December 1, 1899, by Dr. W. L. Abbott. Original number, 101.

*Characters*.—Like *Sciurus davisoni* (Bonhote) but smaller and with scarcely a trace of the reddish areas on neck and sides.

*Color*.—Type: back and sides a uniform grizzle of black and a brown intermediate between the buff and cinnamon of Ridgway, the lighter color somewhat in excess. Face, legs, and feet a finely grizzled gray approaching in general effect the hair-brown of Ridgway and forming a distinct though not very striking contrast with color of back. Neck with a barely indicated reddish area behind and below ear. Ears slightly more gray than back. Underparts dull gray much like that of legs, but distinctly washed with broccoli-brown on middle of belly. Tail concolor with back above, slightly paler below, the grizzle everywhere more coarse and forming obscure cross-bars beyond middle; pencil clear black, equal to about one-sixth entire length of tail.

*Skull and teeth*.—As compared with that of *Sciurus davisoni* the skull of *S. lancavensis* is noticeably smaller and the rostrum is relatively shorter and broader. Teeth essentially as in *S. davisoni*.

*Measurements*.—Measurements of type: total length, 410; head and body, 210; tail vertebræ, 200; hind foot, 51 (47.5); skull,

<sup>1</sup> Measurements in parenthesis are those of one of the cotypes (adult male) of *Sciurus fraterculus*, taken from the original description.

greatest length, 53; zygomatic breadth, 29.4; median length of nasals, 15.6; greatest breadth of both nasals together, 7.6.<sup>1</sup>

*Specimens examined*.—Two, both from Pulo Lankawi.

#### SCIURUS ADANGENSIS sp. nov.

1900. *Sciurus concolor* MILLER, Proc. Biol. Soc. Washington, XIII, p. 191, December 21, 1900. Part, specimens from Pulo Adang. Not *Sciurus concolor* BLYTH.

*Type*.—Adult male (skin and skull), No. 104,389, United States National Museum. Collected on Pulo Adang, Butang Islands, December 14, 1899, by Dr. W. L. Abbott. Original number, 153.

*Characters*.—Like *Sciurus lancavensis* but smaller.

*Color*.—The color so closely resembles that of *Sciurus lancavensis* as to require no special description. The sides of the neck are almost exactly concolor with back, and I can detect no trace of a reddish area along sides of body.

*Skull and teeth*.—The skull is shorter and relatively broader than that of *Sciurus lancavensis*, but otherwise it does not differ appreciably in form. Teeth as in the related species.

*Measurements*.—Measurements of type: total length, 395; head and body, 210; tail vertebrae, 185; hind foot, 48 (45); skull, greatest length, 51; zygomatic breadth, 30; median length of nasals, 14.8; greatest breadth of both nasals together, 7.

*Specimens examined*.—Three, all from Pulo Adang.

#### SCIURUS SULLIVANUS sp. nov.

*Type*.—Adult female (skin and skull), No. 104,377, United States National Museum. Collected on Sullivan Island, Mergui Archipelago, February 1, 1900, by Dr. W. L. Abbott. Original number, 294.

*Characters*.—Similar to *Sciurus davisoni* (Bonhote) from southern Tenasserim, but smaller and darker.

*Color*.—Type: back a fine grizzle of black, buff, and raw-sienna, the last slightly in excess of either of the others. On sides of neck and along sides of body from axilla to inner surface of thigh the color deepens nearly to ochraceous-rufous which forms a very evident contrast with the surrounding parts. Ears, head, legs, and feet grizzled gray, somewhat resembling the mouse-gray of Ridgway but with a silvery gloss. Underparts dull smoke-gray,

<sup>1</sup> In an adult male *Sciurus davisoni* from Bok Pyin, Tenasserim (No. 104,392), the skull measures: greatest length, 57; zygomatic breadth, 32; median length of nasals, 17.4; greatest breadth of both nasals together, 7.6.

with an indistinct darker wash along median line. Tail like back, but more coarsely grizzled, its terminal black area occupying about one-fourth total length of tail.

*Skull and teeth.*—The skull closely resembles that of *Sciurus adangensis* in form, but in size it is distinctly larger. It is smaller and less elongate than the skull of *Sciurus davisoni*. The teeth show no peculiarities.

*Measurements.*—Measurements of type: total length, 490; head and body, 285; tail vertebræ, 205; hind foot, 51 (47); skull, greatest length, 55; zygomatic breadth, 33; median length of nasals, 16.8; greatest breadth of both nasals together, 7.8.

*Specimens examined.*—Five, all from Sullivan Island.

*Remarks.*—The series shows no variation worthy of note. The color pattern in this species is like that of the mainland animal, and the neck and side markings show no tendency to become obsolete.

#### SCIURUS DOMELICUS sp. nov.

*Type.*—Adult female (skin and skull), No. 104,381, United States National Museum. Collected on Domel Island, Mergui Archipelago, February 24, 1900, by Dr. W. L. Abbott. Original number, 322.

*Characters.*—Like *Sciurus sullivanus* but colors throughout slightly darker, reddish lateral areas spreading over whole ventral surface, black tip of tail longer, and skull with narrower, more elongate rostrum.

*Color.*—Type: The colors are essentially as in *Sciurus sullivanus* but are all a shade darker, the red of the sides and neck approaching cinnamon-rufous. Entire underparts heavily washed with dull cinnamon-rufous, a trace of grizzled gray, however, remaining on chest. Legs, feet, and face darker gray than in the related form, but rather lighter and producing a more decided contrast. Tail as in *Sciurus sullivanus* except that the black terminal area is noticeably longer.

*Skull and teeth.*—The skull differs from that of *Sciurus sullivanus* in its narrower general form, and in the greater elongation of the rostrum. Its resemblance to the skull of *Sciurus lancavensis* is very close.

*Measurements.*—Measurements of type: total length, 420; head and body, 210; tail vertebræ, 210; hind foot, 51 (48); skull, greatest length, 54; zygomatic breadth, 31; median length of nasals, 16.4; greatest breadth of both nasals together, 7.

*Specimens examined.*—Two, both from Domel Island.

**SCIURUS BENTINCANUS** sp. nov.

*Type*.—Adult female (skin and skull), No. 104,383, United States National Museum. Collected on Bentinck Island, Mergui Archipelago, March 11, 1900, by Dr. W. L. Abbott. Original number, 349.

*Characters*.—External appearance essentially as in *Sciurus davisoni* but size somewhat greater, and skull with larger, more inflated audital bullæ.

*Color*.—Type: The color so closely resembles that of *Sciurus davisoni* from southern Tenasserim that no detailed description is necessary. The reddish area on sides and neck is, however, slightly more intense, approaching the ferruginous of Ridgway. In the type specimen the posterior half of the back is in a dull worn pelage slightly contrasting with the fresh coat on other parts of the body. Chest and belly with a distinct reddish wash, but this is not sufficiently heavy to obscure the usual grizzled gray.

*Skull and teeth*.—In size and general outline the skull does not differ appreciably from that of *Sciurus davisoni*, but the audital bullæ are distinctly larger and more inflated, a character that is particularly noticeable when the skull is viewed from below. The width of the anterior half of the bullæ in this aspect is fully 1 mm. greater in the island species. The teeth show no peculiarities.

*Measurements*.—Measurements of type: total length, 465; head and body, 235; tail vertebræ, 230; hind foot, 57 (53); skull, greatest length, 58; zygomatic breadth, 33.

*Specimens examined*.—Three, all from Bentinck Island.

**SCIURUS MATTHÆUS** sp. nov.

*Type*.—Adult female (skin and skull), No. 111,920, United States National Museum. Collected on St. Matthew Island, Mergui Archipelago, December 11, 1900, by Dr. W. L. Abbott. Original number, 774.

*Characters*.—Similar to *Sciurus bentincanus* but not as large and with reddish areas on neck and sides less strongly marked.

*Color*.—Type: The color throughout is exactly similar to that of *Sciurus bentincanus* except that the reddish areas on neck and sides are slightly duller and less strongly contrasted with surrounding parts.

*Skull*.—The skull is similar to that of *Sciurus bentincanus* in form, though the size is much less. Notwithstanding the size of the skull the bullæ are fully as large as those of *Sciurus davisoni*. The teeth show no peculiarities.

*Measurements.*—Measurements of type: total length, 445; head and body, 220; tail vertebræ, 225; hind foot, 53 (50); skull, greatest length, 54; zygomatic breadth, 31.

*Specimens examined.*—Four, all from St. Matthew Island.

**SCIURUS LUCAS** sp. nov.

*Type.*—Adult female (skin and skull), No. 104,385, United States National Museum. Collected on St. Luke Island, Mergui Archipelago, January 20, 1900, by Dr. W. L. Abbott. Original number, 256.

*Characters.*—Similar to *Sciurus matthæus*, but ground color of upperparts and tail strongly suffused with fulvous.

*Color.*—Type: general color above dull, light tawny-ochraceous, grizzled by the black hair-tips and buff subterminal annulations. Sides of neck and of body ferruginous, lighter than that of Ridgway and forming no very marked contrast with color of back. The ferruginous of neck is a little brighter than that of body. Tail like back, but more coarsely grizzled, the black terminal pencil well developed.

*Skull and teeth.*—The skull and teeth exactly resemble those of *Sciurus matthæus*.

*Measurements.*—Measurements of type: total length, 430; head and body, 220; tail vertebræ, 210; hind foot, 54 (50); skull, greatest length, 54; zygomatic breadth, 31.

*Specimens examined.*—Two, both from St. Luke Island.

*Remarks.*—Little though it would be anticipated, the squirrel of St. Luke Island differs very noticeably from that of St. Matthew. The characters are perfectly constant so far as the rather small number of specimens is concerned, and from the known stability of the colors in other members of the group there is no reason to suppose that the differences are merely individual.

**SCIURUS CASENSIS** sp. nov.

*Type.*—Adult female (skin and skull), No. 104,370, United States National Museum. Collected on Chance Island, Mergui Archipelago, December 28, 1899, by Dr. W. L. Abbott. Original number, 185.

*Characters.*—Like *Sciurus davisoni* (Bonhote), but size larger, color, particularly that of tail, paler, and reddish areas of neck and sides brighter and more strongly contrasted with surrounding parts.

*Color.*—Type: back and crown a fine grizzle of black and light buff, the latter slightly in excess. On sides this becomes suffused

with dull ferruginous which increases rapidly in intensity to form an almost clear ferruginous lateral stripe. Neck patch bright ferruginous, strongly contrasted with surrounding parts. Hind legs like back except that inner posterior surface is heavily washed with clear ferruginous. Front legs a clear silvery grizzle of ecru-drab and whitish smoke-gray. Underparts dull buffy gray washed with pale ferruginous on chest. A large, clear, orange-rufous area at groin. Tail distinctly paler than back, the light annulations of the hairs whitish cream-buff on dorsal surface, pale buff below. Black pencil well developed.

*Skull and teeth.*—The skull closely resembles that of *Sciurus davisoni* but is slightly larger, the rostrum is broader and the audital bullæ are more inflated anteriorly. Teeth as in the related species.

*Measurements.*—Measurements of type: total length, 465; head and body, 250; tail vertebræ, 215; hind foot, 52 (48); skull, greatest length, 57; zygomatic breadth, 33.

*Specimens examined.*—Five, all from Chance Island.

*Remarks.*—Its large size, pale color, the contrast between the upper surface of the tail and the back, and the brightness and distinctness of the ferruginous markings make this species one of the most strongly characterized in the group. The series of skins shows no variations worthy of note.

#### SCIURUS ALTINSULARIS sp. nov.

*Type.*—Adult female (skin and skull), No. 111,975, United States National Museum. Collected on High Island, Mergui Archipelago, December 31, 1900, by Dr. W. L. Abbott. Original number, 810.

*Characters.*—General appearance as in *Sciurus casensis*, but size smaller, general color paler, upper surface of tail not lighter than back, and ferruginous markings replaced by ochraceous-buff.

*Color.*—Type: back, sides, head, and both surfaces of tail a fine grizzle of black and cream-buff, the latter everywhere in excess and palest on head, darkest on tail. Neck patch dull ochraceous-buff, slightly contrasted with color of surrounding parts. Sides strongly tinged with ochraceous-buff in region between axilla and groin. Underparts smoke-gray, grizzled with broccoli-brown along median line of chest. A small, clear ochraceous-buff area at axilla and another at groin. Inner surface of legs like belly, outer surface and feet somewhat darker. Tail with black pencil well developed.

*Skull and teeth.*—The skull resembles that of *Sciurus casensis* but is distinctly smaller. Teeth not peculiar.

*Measurements.*—Measurements of type: total length, 437; head

and body, 230; tail vertebræ, 207; hind foot, 50 (47); skull, greatest length, 54.6; zygomatic breadth, 31.

*Specimens examined*.—Five, all from High Island.

**SCIURUS RUBECULUS** sp. nov.

*Type*.—Adult male (skin and skull), No. 86,777, United States National Museum. Collected at Khov Sai Dow, Trong, Lower Siam, altitude 1000 feet, February 21, 1899, by Dr. W. L. Abbott.

*Characters*.—Similar to *Sciurus atrodorsalis* Gray, but much larger. No black-backed phase at present known.

*Color*.—Type: upperparts a clear fine grizzle of black and ochraceous, the latter somewhat in excess. On sides, legs, cheeks, throat, and along median line from chest to base of tail the ochraceous element of the grizzle is lighter and duller than on the back, approaching the ochraceous-buff of Ridgway. Underparts (except the grizzled area) and inner side of legs nearly to feet, bright orange-rufous, darker and more red than that of Ridgway. The red area is completely divided by the grizzled median line. This is about 10 mm. in width. Ears like back. Front feet concolor with legs, hind feet slightly darker. Whiskers black. Tail like back but more coarsely grizzled. On terminal half and pencil the tail is fringed with clear orange-rufous due to a subterminal annulation of this color on each hair. The extreme tips of the hairs forming the fringe are for the most part black, but this color is easily overlooked. On terminal third of tail there is a slight tendency toward the formation of black cross-bars, and on under side through same region two faint black bands may be traced parallel with edge.

*Skull and teeth*.—As compared with a skull of *Sciurus atrodorsalis* from Kokareet, Tenasserim, that of *S. rubeculus* is immediately distinguishable by its greater size, and by the relatively shorter broader rostrum. The audital bullæ on the other hand scarcely exceed those of the smaller animal in size, while in form they are less inflated. Frontals nearly flat anteriorly, not distinctly concave as in the allied form. Teeth as in *Sciurus atrodorsalis*.

*Measurements*.—Measurements of type: total length, 440; head and body, 230; tail, 210; hind foot, 51 (48); skull, greatest length, 55 (50);<sup>1</sup> basal length, 49 (42); zygomatic breadth, 33 (29.6); least interorbital breadth, 20.4 (17); median length of nasals, 14.8 (14.6); greatest breadth of both nasals together, 8 (7).

*Specimens examined*.—Five, from the following localities: Trong, one, the type; Tenasserim, Bok Pyin, 3, Sungei Balik, 1.

<sup>1</sup> Cranial measurements in parenthesis are those of an adult female *Sciurus atrodorsalis* from Kokareet, Tenasserim (No.  $\frac{37461}{27380}$ ).





1. *Sciuropterus mærens*, type. 2. *Funambulus obscurus*, type.



*Remarks.*—The United States National Museum contains specimens of two readily distinguishable squirrels identified as *Sciurus atrodorsalis* by Mr. Oldfield Thomas. The first is from Kokareet, Tenasserim, and is one of the series recorded in the "Annali del Museo Civico di Storia Naturale di Genova" for 1892 (vol. xxx, p. 929). The second is the type of *Sciurus rubeculus*, identified at my request. While there can be no question as to the close relationship and general superficial likeness of the two specimens, due allowance being made for the fact that the Tenasserim skin is in the black-backed pelage, the cranial differences are such as to make their separation necessary. It seems highly improbable that the Kokareet animal is the same as true *Sciurus atrodorsalis*, the type of which came from Bhotan, but the latter, as well as *Sciurus gordonii* Anderson and *S. hyperythrus* Blyth, appears to agree with it and to differ from *Sciurus rubeculus* in markedly smaller size.

**FUNAMBULUS OBSCURUS** sp. nov.

(PLATE I, FIGURE 2)

*Type.*—Adult female (skin and skull), No. 121,640, United States National Museum. Collected on South Pagi Island, Sumatra, November 22, 1902, by Dr. W. L. Abbott. Original number, 2086.

*Characters.*—About the size of *Funambulus insignis*, but tail much shorter. Color darker than in the Sumatran animal, dark lateral stripes obsolete, and underparts iron gray. Skull with unusually elongate rostrum.

*Color.*—Type: back and sides a uniform, very fine grizzle of black and light ochraceous, the latter slightly in excess. Outer surface of hind legs similar to back, but that of front legs slightly darker. Crown and cheeks a little darker than back, the cheeks perceptibly tinged with gray. Feet and ears blackish. Median black dorsal stripe about 3 mm. wide. It is well defined, and extends from about middle of neck to lumbar region. Lateral stripes reduced to mere dark shades too indistinct to be measured, or to have any definite color. They are about 10 mm. distant from the median stripe, and of approximately the same length as the latter. Underparts and inner surface of legs a grizzled iron gray. This is darker and less grizzled on legs and along sides of belly, much lighter and with a frosted appearance on throat and chest. The darker gray about matches the slate-gray of Ridgway, the lighter cannot be accurately described. Tail like back but very coarsely grizzled. Above the ochraceous predominates in the middle and the black forms a border 10 mm. wide. The extreme tips of the

hairs at the edge are black, but there is a noticeable ochraceous subterminal band. Pencil black. Beneath the black predominates uniformly.

*Skull and teeth.*—While the skull in a general way resembles that of *Funambulus insignis* the peculiarities of the latter as compared with true *Sciurus* are in it much exaggerated. The rostrum is greatly elongated, so much so that the skull would hardly at first glance be recognized as that of a squirrel. This elongation, however, does not approach that of the rostrum in *Rhinosciurus*. In *Funambulus insignis* the distance from anterior rim of orbit to tip of nasals is about equal to breadth of braincase above roots of zygomata, while in *F. obscurus* it is decidedly greater than this breadth, though not, as in *Rhinosciurus*, approximately the same as the zygomatic breadth. The nasals are strongly rounded from tip nearly to base, so much so that near middle they almost form a ridge. Only the extreme proximal end is flat. Zygomata decidedly heavier than in *Funambulus insignis*, but not peculiar in form. Teeth similar to those of the related species but larger throughout.

*Measurements.*—External measurements of type: total length, 303; head and body, 220; tail vertebræ, 83; hind foot, 44 (42); ear from meatus, 14; ear from crown, 7; width of ear, 11.6.

Cranial measurements of type: greatest length, 53.6; basal length, 45; basilar length, 43; palatal length, 24; diastema, 14.4; distance from anterior rim of orbit to tip of nasals, 25; length of nasals, 18.4; greatest breadth of both nasals together, 6.2; least breadth of both nasals together, 4; least interorbital breadth, 14; zygomatic breadth, 30; breadth of braincase above roots of zygomata, 20; mandible, 34; maxillary toothrow (alveoli), 10; mandibular toothrow (alveoli), 10.

*Specimens examined.*—Seven, all from the Pagi Islands.

*Remarks.*—The skins are very uniform in color. Practically the only variation shown by the series is in the distinctness of the lateral dark stripes. In four of the specimens these are nearly as well developed as the median stripe, but in none of them is there any close resemblance to *Funambulus insignis*.

#### FUNAMBULUS ROSTRATUS sp. nov.

*Type.*—Adult female (skin and skull), No. 121,801, United States National Museum. Collected on Tana Bala, Batu Islands, February 12, 1903, by Dr. W. L. Abbott. Original number, 2281.

*Characters.*—Similar to *Funambulus insignis*, but color slightly darker, black dorsal stripes apparently broader, and skull with more elongate rostrum.

*Color.*—Dorsal surface a uniform, fine grizzle of black and buff, the latter in excess everywhere except on rump, shoulders, neck, and head. Black stripes well developed, about 7 mm. wide at middle of back, extending from middle of neck to lumbar region, the median faintly prolonged to crown. Region between stripes exactly similar to that outside, but appearing lighter by contrast with the black. Cheeks and outer surface of legs duller and more finely grizzled than back. Feet dark hair-brown. Hairs of tail annulated with black and orange-buff, the general effect a coarse grizzle of the two colors. Underparts and inner surface of legs cream-buff, slightly more yellow than that of Ridgway.

*Skull and teeth.*—The skull is larger than that of *Funambulus insignis*, the interorbital region is relatively broader, and the rostrum is more produced. In the last character there is a close approach to *Funambulus obscurus*, but the nasals are flat posteriorly, as in *F. insignis*. Teeth as in *Funambulus insignis*, but somewhat larger.

*Measurements.*—External measurements of type: total length, 265;<sup>1</sup> head and body, 197; tail vertebræ, 68;<sup>1</sup> hind foot, 45 (41); ear from meatus, 15.6; ear from crown, 9; width of ear, 13.

Cranial measurements of type: greatest length, 51.6 (49);<sup>2</sup> basal length, 43 (41); basilar length, 40 (38.8); palatal length, 22.8 (21.4); diastema, 14 (12.2); length of nasals, 17 (16); greatest breadth of both nasals together, 6.6 (6.4); interorbital breadth, 14 (12.4); distance between tips of postorbital processes, 22.4 (20); zygomatic breadth, 30 (26);<sup>3</sup> breadth of braincase above roots of zygomata, 22 (20.6);<sup>3</sup> greatest depth of braincase, 17 (16); mandible, 33 (30); maxillary toothrow (alveoli), 9.4 (9); mandibular toothrow (alveoli), 10 (9).

*Specimens examined.*—One, the type.

*Remarks.*—The Batu *Funambulus* is readily distinguishable from the Sumatran *F. insignis* by its darker color and larger skull. For the opportunity to examine two skins and a skull of the Sumatran animal I am indebted to the Academy of Natural Sciences of Philadelphia, through the kindness of Mr. Witmer Stone.

#### FUNAMBULUS PENINSULÆ sp. nov.

*Type.*—Adult male (skin and skull), No. 86,776, United States National Museum. Collected at Khow Sai Dow, Trong, Lower Siam, February 18, 1899, by Dr. W. L. Abbott.

<sup>1</sup>Tail apparently imperfect.

<sup>2</sup>Measurements in parenthesis are those of an adult male *Funambulus insignis* from Gunong Sugi, Lampong District, Sumatra (No. 6655, Academy of Natural Sciences of Philadelphia).

<sup>3</sup>Approximate.

*Characters*.—General color lighter and brighter than in *Funambulus insignis*. Skull larger than in the Sumatran animal, but similar to it in form.

*Color*.—The light element in the grizzle of the upperparts is brighter and more yellow than that in *Funambulus insignis* and *F. rostratus*. The exact tint is very close to the raw-sienna of Ridgway, except in the neighborhood of the black stripes, where it is diluted with cream-buff. Front feet hair-brown. Hind feet hair-brown grizzled with yellowish. The light bands on the hairs of the tail are dull raw-sienna, but the tips are grayish. Underparts cream-buff, fading almost to white on chest, and darkening to buff on inner surface of hind legs.

*Skull and teeth*.—The skull is distinctly larger than that of *Funambulus insignis* and the interorbital region is broader, but otherwise it shows no peculiarities. Teeth as in *Funambulus insignis*.

*Measurements*.—Measurements of type: total length, 295; head and body, 195; tail vertebræ, 100; hind foot, 44 (41); skull, greatest length, 50; length of nasals, 16; diastema, 12; interorbital breadth, 14.4; zygomatic breadth, 28; mandible, 30; maxillary toothrow (alveoli), 8.8; mandibular toothrow (alveoli), 9.

*Specimens examined*.—One, the type.

#### SCIUROPTERUS MÆRENS sp. nov.

(PLATE I, FIGURE I)

*Type*.—Adult female (skin and skull), No. 121,531, United States National Museum. Collected on North Pagi Island, Sumatra, January 14, 1902, by Dr. W. L. Abbott. Original number, 2206.

*Characters*.—Like *Sciuropterus lugens* Thomas, but ear much smaller and color not as dark.

*Color*.—Entire animal drab, the back and tail darker than Ridgway's plate III, fig. 18, the underparts lighter and more bluish, closely approaching ecru-drab. In certain lights the shoulders, neck, and head show a distinct wash of wood-brown or isabella-color. Throughout dorsal surface the underfur is bluish gray. Tail unicolor throughout, except at extreme base below, where it is like belly. Feet and lower portion of legs so thinly haired as not to conceal the skin, the hairs dull light drab. Ears and whiskers blackish. Claws light horn-color.

*Ears*.—The ears agree in form with those of *Sciuropterus lugens* as described by Thomas, except that the posterior border is very slightly concave. In size they are much smaller, measuring only



3

2

1



4

5

1. *Petaurista nitida*, male, No. 104,622, Bunguran Island, North Natunas. 2. *Petaurista nitida*, male, No. 121,499, eastern Java. 3. *Petaurista batuanua*, male (type). 4. *Atherura zygomatica*, female (type). 5. *Atherura macroura*, female, No. 84,433, Trong, Lower Siam.



15.4 mm. from meatus, and 8 mm. from crown. The measurements given in the original description of *S. lugens* are 21.5 and 20 for an adult male and female respectively.

*Skull and teeth.*—So far as can be judged from the description the skull and teeth (pl. 1, fig. 1) agree with those of *Sciuropterus lugens*. Audital bullæ very broad and flat.

*Measurements.*—External measurements of type: total length, 485; head and body, 265; tail vertebrae, 220; hind foot, 49 (44); ear from meatus, 15.4; ear from crown, 8; width of ear, 7.6.

Cranial measurements of type: greatest length, 48.8; basal length, 41.4; basilar length, 38; median palatal length, 22; diastema, 10; length of nasals, 14.8; greatest breadth of both nasals together, 7.8; interorbital breadth, 11; distance between tips of postorbital processes, 23; zygomatic breadth, 29; breadth of braincase above roots of zygomata, 20.6; greatest depth of braincase, 16.4; occipital depth, 12; mandible, 29; maxillary toothrow (alveoli), 10; mandibular toothrow (alveoli), 10.

*Specimens examined.*—One, the type.

*Remarks.*—While this squirrel is evidently a near ally of the Siporan *Sciuropterus lugens*, it is readily distinguishable by its smaller ear and less dark color. It needs no comparison with any other species.

**PETAURISTA BATUANA sp. nov.**

(PLATE II, FIGURE 3)

*Type.*—Adult male (skin and skull), No. 121,742, United States National Museum. Collected on Tana Bala, Batu Islands, Sumatra, February 5, 1903, by Dr. W. L. Abbott. Original number, 2233.

*Characters.*—Like *Petaurista nitidula* of the Natuna Islands, but intermediate in size between this species and the large Javan *P. nitida*.

*Color.*—Type: upperparts deep rufous or ferruginous, a little darkened, particularly along median line, by blackish hair-tips. Upper side of membranes and outer surface of legs burnt-sienna, darkening to black on feet, wrists, ankles, and outer edge of forearm. Edge of interfemoral membrane blackish brown. Underparts and inner surface of thighs and upperarms pale ochraceous-rufous. Chin blackish. On cheeks and muzzle the rufous and ochraceous-buff are mixed together and slightly tinged with gray. Ears rufous internally, black externally. A small blackish area behind ear. Eye ring and area surrounding muzzle and base of whiskers black. Edge of flying membrane dull ochraceous-buff.

Tail intermediate between the ochraceous-buff of belly and the rufous of back, the tip black.

*Skull and teeth.*—The skull and teeth (pl. II, fig. 3) exactly resemble those of *Petaurista nitida* (pl. II, fig. 2) and *P. nitidula* (pl. II, fig. 1), but are intermediate in size, though perhaps most nearly approaching the Javan animal.

*Measurements.*—External measurements of type: total length, 825; head and body, 405; tail vertebræ, 420; hind foot, 75 (68); ear from meatus, 35; ear from crown, 24.6; width of ear, 16.

Cranial measurements of type: greatest length, 66.4 (72);<sup>1</sup> basal length, 60 (65); basilar length, 56 (60); length of nasals, 20 (22.4); greatest breadth of both nasals together, 11.8 (12.8); median palatal length, 32.6 (33.6); diastema, 15 (16); interorbital breadth, 15.4 (16); distance between tips of postorbital processes, 36 (36); zygomatic breadth, 46.4 (49); breadth of braincase above roots of zygomata, 28.6 (28); greatest depth of braincase, 22 (23.6); occipital depth, 17 (17.4); mandible, 44 (49.6); maxillary toothrow (alveoli), 16 (16); mandibular toothrow (alveoli), 16.2 (17).

*Specimens examined.*—Eight, all from the Batu Islands. Seven are from Tana Bala, the other from Tana Masa.

*Remarks.*—While *Petaurista batuana* is more like *P. nitida* in size, its color is much lighter than that of the large Javan animal. It is not quite as light, however, as the small *P. nitidula* of the Natunas, though in all respects except size it very closely resembles this form.

#### MUS STRIDENS sp. nov.

1900. *Mus vociferans* MILLER, Proc. Wash. Acad. Sci., II, p. 208, August 20, 1900. Tioman Island. Not *M. vociferans* MILLER, April 21, 1900.

*Type.*—Adult male (skin and skull), No. 104,992, United States National Museum. Collected on Tioman Island, off southeast coast of Malay Peninsula, October 10, 1900, by Dr. W. L. Abbott. Original number, 702.

*Characters.*—Similar to *Mus strepitans* of the Anamba Islands, but ears larger and color not as dark.

*Color.*—The color so closely resembles that of *Mus strepitans*<sup>2</sup> that no detailed description is necessary. The ochraceous-buff of back and sides is distinctly paler than in the Anamba animal, and the sprinkling of blackish hairs is less noticeable. Underparts and inner

<sup>1</sup> Measurements in parenthesis are those of an adult male *Petaurista nitida* from western Java (No. 121,499).

<sup>2</sup> See Proc. Wash. Acad. Sci., II, pp. 207–208, August 20, 1900.

surface of legs pale straw-yellow, not whitish as in *Mus vociferans*, the mainland form.

*Measurements*.—External measurements of type: total length, 570 (550);<sup>1</sup> head and body, 254 (229); tail vertebræ, 316 (318); hind foot, 46 (45.6); hind foot without claws, 44 (44); ear from meatus, 28 (23); ear from crown, 22 (18).

*Specimens examined*.—Nine, all from Tioman Island.

*Remarks*.—This rat is a well marked form of the *sabanus-vociferans* group. In most characters it is intermediate between the bright *Mus vociferans* of Lower Siam and the dull dark *M. strepitans* of the Anamba Islands, but it appears to differ from both in the large size of the ears.

#### MUS MATTHÆUS sp. nov.

*Type*.—Adult male (skin and skull), No. 104,159, United States National Museum. Collected on St. Matthew Island, Mergui Archipelago, January 18, 1900, by Dr. W. L. Abbott. Original number, 243.

*Characters*.—A large member of the *sabanus-vociferans* group, differing from *Mus vociferans* in the duller, more rusty color of the back and sides, and strongly yellowish underparts. Blackish hairs of upperparts not as dark as in the mainland form.

*Color*.—The color is essentially as in *Mus vociferans*<sup>2</sup> except that the ground color of back and sides is tawny instead of ochraceous or tawny-ochraceous, and the dark hairs with which the back is sprinkled are distinctly brownish, while in the related species they are nearly black. Underparts and inner surface of legs cream-buff.

*Measurements*.—Measurements of type: total length, 600; head and body, 248; tail vertebræ, 350; hind foot, 50 (48); ear from meatus, 27; ear from crown, 21; skull, greatest length, 56; zygomatic breadth, 25.

*Specimens examined*.—Twelve (one skull without skin), all from St. Matthew Island.

*Remarks*.—In its dark, rich color this rat is strikingly different from the other members of the *sabanus-vociferans* group occurring in the Mergui Archipelago, all of which, so far as known, are paler than the mainland form.

#### MUS STRIDULUS sp. nov.

*Type*.—Adult female (skin and skull), No. 104,196, United States National Museum. Collected on Bentinck Island, Mergui Archi-

<sup>1</sup>Measurements in parenthesis are those of an adult male *Mus strepitans* from Pulo Jimaja, Anamba Islands (No. 101,736).

<sup>2</sup>See *Proc. Biol. Soc. Washington*, XIII, p. 138, April 21, 1900.

pelago, March 12, 1900, by Dr. W. L. Abbott. Original number, 350.

*Characters.*—A light-colored member of the *sabanus-vociferans* group, with disproportionately small feet.

*Color.*—The ground color of back and sides is buff, rather darker and brighter than that of Ridgway, but scarcely approaching ochraceous. Back rather thickly sprinkled with dark brown hairs, sides much less so. Underparts cream-buff.

*Measurements.*—Measurements of type: total length, 514; head and body, 222; tail vertebræ, 292; hind foot, 41 (38.6); ear from meatus, 25.4; ear from crown, 20; skull, greatest length, 52; zygomatic breadth, 24. Hind foot in two other adult females, 41.4 (39.6) and 40 (38). Hind foot in two adult males, 42 (40) and 41.6 (39.4).

*Specimens examined.*—Six, all from Bentinck Island.

#### MUS LUCAS sp. nov.

*Type.*—Adult female (skin and skull), No. 104,190, United States National Museum. Collected on St. Luke Island, Mergui Archipelago, January 20, 1900, by Dr. W. L. Abbott. Original number, 253.

*Characters.*—Similar to *Mus stridulus* but with feet of normal size.

*Color.*—The color is almost exactly the same as that of *Mus stridulus* from Bentinck Island, though perhaps a trifle more yellowish. It is therefore strikingly different from that of the dark *Mus mattheus* of St. Matthew Island.

*Measurements.*—Measurements of type: total length, 525; head and body, 215; tail vertebræ, 309; hind foot, 46 (44); ear from meatus, 26; ear from crown, 22; skull, greatest length, 52.4; zygomatic breadth, 23.

*Specimens examined.*—Three, all from St. Luke Island.

*Remarks.*—While this species differs widely from its near geographical ally *Mus mattheus* it rather closely resembles the *Mus lancavensis* of Pulo Lancawi. It is distinguishable from the latter by the more reddish cast of the upperparts, and by the less conspicuous grizzle produced by the dark hairs of the back.

#### MUS SOCCATUS sp. nov.

*Type.*—Adult male (skin and skull), No. 121,549, United States National Museum. Collected on North Pagi Island, Sumatra, December 29, 1902, by Dr. W. L. Abbott. Original number, 2183.

*Characters.*—A large, very dark member of the *sabanus-vociferans*

group, closely similar to *Mus siporanus* Thomas, but with rufous of upperparts replaced by dull buff.

*Color.*—Type: back and sides a mixture of blackish brown and dull buff, the former predominating on neck, shoulders, and fore part of back, and completely excluding the buff on lumbar region, rump, and about base of tail, the latter predominating on sides of neck and body, particularly in region of shoulders. Throughout the dorsal surface the hairs are ecru-drab at base. Crown, muzzle, and cheeks to level of lower eyelid glossy brownish black, lower half of cheeks like sides of body but more finely grizzled and somewhat darker. Ears and whiskers black. Outer surface of legs like sides proximally, but soon darkening to blackish brown, a color which covers entire dorsal surface of feet. Underparts whitish cream-buff to base of hairs. A narrow hair-brown median streak 30 mm. in length on lower portion of throat. Chest slightly discolored by a brownish stain. The color of belly extends down inner side of front leg to foot, but on hind leg it is abruptly cut off a little above middle of tibia by the blackish brown of lower half of leg. Tail blackish brown above to middle, whitish throughout terminal half. The under side of the basal half is irregularly marbled with whitish and brown.

*Mammæ.*—Mammæ 8, four pectoral and four inguinal.

*Fur.*—The quality of the fur is as in *Mus vociferans*, *M. sabanus*, and their relatives. The flattened, grooved hairs are so numerous as to give the fur a coarse, harsh texture, but they do not resemble bristles. Rump and lumbar region without noticeably elongated hairs.

*Skull and teeth.*—The skull resembles that of the members of the *sabanus-vociferans* group, but is distinguishable by its large size, relatively short, wide, incisive foramina, and by the unusually broad, rounded, angular process of the mandible. Teeth as in *Mus vociferans*, but larger.

*Measurements.*—External measurements of type: total length, 592; head and body, 276; tail vertebræ, 316; hind foot, 53 (50); ear from meatus, 24; ear from crown, 18; width of ear, 16. External measurements of an adult female (No. 121,540) from the type locality: total length, 562; head and body, 267; tail vertebræ, 295; hind foot, 52 (49.6).

Cranial measurements of type: greatest length, 58; basal length, 50; basilar length, 47; diastema, 15; length of incisive foramen, 7.8; combined breadth of incisive foramina, 3.8; length of nasals, 23; least interorbital breadth, 10; zygomatic breadth, 27; mandible, 32.6; maxillary toothrow (alveoli), 10.2; mandibular toothrow (alveoli), 10.2.

*Specimens examined.*—Twenty-four (6 skulls without skins), all from the Pagi Islands.

*Remarks.*—This is the largest and most conspicuous member of the *sabanus-vociferans* group that has yet come to my notice. It is evidently a near relative of *Mus siporanus* of Sipora Island, but the color is without trace of rufous. The series presents little variation in the color of the upperparts, and such as there is consists chiefly in the greater or less extent of the black lumbar area. On the underparts the brown median chest line is better developed in some specimens than in others, though it is apparently never absent. In one skin (female, No. 121,539) it extends back to middle of belly. In most of the specimens there is a trace of the brown stain on the chest, and in four a bright yellow wash covers parts of the belly and even spreads to the posterior half of back. It is undoubtedly due to stain.

**MUS MASÆ sp. nov.**

*Type.*—Adult female (skin and skull), No. 121,822, United States National Museum. Collected on Tana Masa, Batu Islands, February 21, 1903, by Dr. W. L. Abbott. Original number, 2327.

*Characters.*—A small member of the *sabanus-vociferans* group, with dull ochraceous back and sides, whitish underparts, and wholly brown tail. Skull like that of *Mus soccatus*, but not as large. Mammæ, 8.

*Fur.*—The quality of the fur is as in the members of the *sabanus-vociferans* group, that is, the flattened, grooved hairs, while not stiff enough to form spines, are so numerous as to make the fur coarse and harsh. The hairs of the rump and lumbar region are elongated, but not conspicuously so.

*Mammæ.*—Mammæ 8, four pectoral and four inguinal.

*Color.*—Back and sides mixed blackish brown and pale dull ochraceous or yellowish buff, the exact shade of the lighter color not easily defined, but approaching the ochraceous of Ridgway on shoulders, and fading about to buff on sides. Along middle of back the blackish brown predominates, while on sides the buff becomes almost clear. Crown like back, but more finely grizzled, and slightly tinged with gray; cheeks like sides, but duller. Outer surface of legs like sides, but tinged distally with hair-brown. Feet dull indefinite light brown. Underparts and inner surface of legs white tinged with cream-buff. Ears and tail dark brown, the latter not as dark below as above, but in no way bicolor.

*Skull and teeth.*—Skull almost exactly like that of *Mus soccatus* except that it is not as large; the incisive foramina are relatively

longer and narrower, and the interpterygoid space is narrower throughout and less flaring anteriorly. Teeth as in *Mus soccatus* and the members of the *sabamus-vociferans* group.

*Measurements.*—External measurements of type: total length, 510; head and body, 235; tail vertebræ, 275; hind foot, 43 (41); ear from meatus, 22.4; ear from crown, 17; width of ear, 16.

Cranial measurements of type: greatest length, 54; basal length, 45.4; basilar length, 42.4; diastema, 14.8; length of incisive foramen, 7.8; combined breadth of incisive foramina, 3; length of nasals, 20; least interorbital breadth, 9; zygomatic breadth, 14.6; mandible, 35; maxillary toothrow (alveoli), 10; mandibular toothrow (alveoli), 11.

*Specimens examined.*—Six, all from Tana Masa, Batu Islands.

#### MUS BALÆ sp. nov.

*Type.*—Adult female (skin and skull), No. 121,781, United States National Museum. Collected on Tana Bala, Batu Islands, Sumatra, February 12, 1903, by Dr. W. L. Abbott. Original number, 2274.

*Characters.*—Like *Mus masæ* but not as large; skull with relatively broader rostrum.

*Color.*—The color so closely resembles that of *Mus masæ* as to need no special description.

*Skull and teeth.*—The skull is like that of *Mus masæ*, but the general size is rather less, and the rostrum is actually as well as relatively more robust. Interpterygoid space wider and more expanded anteriorly than in the related species.

*Measurements.*—External measurements of type: total length, 465; head and body, 227; tail vertebræ, 238; hind foot, 41 (38.6); ear from meatus, 23; ear from crown, 18; width of ear, 17.

Cranial measurements of type: greatest length, 52; basal length, 44; basilar length, 42; diastema, 14; length of incisive foramen, 8.2; combined breadth of incisive foramina, 3.4; length of nasals, 20; least interorbital breadth, 9; zygomatic breadth, 25.4; mandible, 32; maxillary toothrow (alveoli), 9.4; mandibular toothrow (alveoli), 9.8.

*Specimens examined.*—Two skins and five skulls, all from Tana Bala.

#### MUS LUGENS sp. nov.

*Type.*—Adult female (skin and skull), No. 121,533, United States National Museum. Collected on North Pagi Island, Sumatra, November 15, 1902, by Dr. W. L. Abbott. Original number, 2046.

*Characters.*—A very large member of the *Mus rattus* group, somewhat closely resembling the *Mus simalurensis* of Simalur Island, but

larger, darker, and less buffy. Skull with audital bullæ actually as well as relatively smaller than in the Simalur rat.

*Color*.—Type: upperparts from muzzle to base of tail bluish black, faintly grizzled with dull buff. On sides the black fades to hair-brown, and the dull buff slightly predominates. Outer surface of legs light hair-brown. Underparts and inner surface of legs smoke-gray, somewhat paler than that of Ridgway. Median line of chest with broccoli-brown streak. Feet dull broccoli-brown. Ears and tail blackish.

*Skull and teeth*.—The skull resembles that of *Mus simalurensis*, but is larger and relatively narrower. The audital bullæ are actually smaller than in *Mus simalurensis* and the groove below and in front of meatus is more strongly developed. Teeth as in *Mus simalurensis*.

*Measurements*.—External measurements of type: total length, 436; head and body, 226; tail vertebræ, 210; hind foot, 41 (38); skull, greatest length, 51.4 (47.4);<sup>1</sup> basal length, 45.4 (41.8);<sup>1</sup> zygomatic breadth, 23.4 (23);<sup>1</sup> interorbital constriction, 7 (7.4);<sup>1</sup> length of nasals, 20 (18).<sup>1</sup>

*Specimens examined*.—Eight, all from the Pagi Islands.

*Remarks*.—The only species with which this rat needs comparison is the *Mus simalurensis* of Simalur Island. It is slightly larger than the Simalur rat, and the underparts lack all trace of buff. The back is also decidedly darker and less distinctly grizzled.

#### MUS JULIANUS sp. nov.

*Type*.—Adult female (skin and skull), No. 112,393, United States National Museum. Collected on St. Julian Island, South China Sea, June 2, 1901, by Dr. W. L. Abbott. Original number, 987.

*Characters*.—A moderate sized, light colored member of the *Mus rattus* group, resembling *Mus siantanicus* of the Anamba Islands in general appearance, but readily distinguishable by the large, globular audital bullæ, short, deep rostrum, and the massive structure of the anterior zygomatic roots.

*Color*.—Upperparts dull yellowish wood-brown, the back darkened by a plentiful sprinkling of blackish and dark hair-brown hairs, the sides lightened by the appearance at surface of ecru-drab under fur. Muzzle and outer surface of legs ecru-drab, the latter faintly washed with wood-brown. Whiskers mixed blackish and whitish. Underparts and inner surface of legs cream-buff, clouded with ecru-drab

<sup>1</sup> Type of *Mus simalurensis*.



laterally and along median line of chest. Feet hair-brown. Ears and tail uniform blackish brown.

*Skull and teeth.*—While of about the same length as that of *Mus siantanicus* the skull differs from that of the Anamba rat, as well as all other members of the group, in its very heavily built rostrum and anterior zygomatic roots. The plate forming outer wall of infraorbital foramen is much wider than in any other species of approximately equal size, and its upper margin is so flaring that the foramen is a very conspicuous feature of the skull when viewed from above. Audital bullæ unusually large, subglobular in outline when skull is viewed from below. Teeth in no way peculiar.

*Measurements.*—Measurements of type: total length, 379; head and body, 190; tail vertebrae, 189; hind foot, 36 (34); ear from meatus, 19.6; ear from crown, 13; width of ear, 14; skull, greatest length, 41; basal length, 37.4; zygomatic breadth, 20.6; interorbital constriction, 7.

*Specimens examined.*—Six (three in alcohol), all from St. Julian Island.

*Remarks.*—This easily recognizable member of the *Mus rattus* group is very different from the large *Mus tambelanicus*, its nearest geographical ally. In size it closely agrees with *Mus siantanicus*, but the cranial characters of the two species are very different.

#### MUS GILBIVENTER sp. nov.

*Type.*—Adult male (skin and skull), No. 104,153, United States National Museum. Collected on Sullivan Island, Mergui Archipelago, February 2, 1900, by Dr. W. L. Abbott. Original number, 295.

*Characters.*—Similar to *Mus cremoriventer* but with coarse, spiny fur resembling in quality that of the members of the *surifer* group.

*Color.*—The elements of the color are exactly as in *Mus cremoriventer*,<sup>1</sup> except that the spines on the back and sides are strongly tinged with cream-buff. These spines everywhere appear conspicuously on the surface instead of being completely hidden by the softer elements of the fur as is the case in *Mus cremoriventer*. The effect on the general color is to produce a peculiar variegated grizzle of ochraceous, light yellowish horn-color, and blackish brown, noticeably different from the more uniform ochraceous of the related species, and suggesting some of the members of the *surifer* group. Cheeks and narrow line along sides bright, clear ochraceous. Belly and inner surface of legs cream-buff rather yellower than that of

<sup>1</sup> See *Proc. Biol. Soc. Washington*, XIII, p. 144, April 21, 1900.

*Mus cremoriventer*. Tail uniform brown throughout, the tip with distinct brown pencil. Neither the skin of the tail nor its hairs are as dark as in the related species. Feet dirty whitish, clouded with brown.

*Skull and teeth*.—The skull resembles that of *Mus cremoriventer*,<sup>1</sup> but is slightly larger; the rostrum is deeper, the incisive foramina are longer, and the audital bullæ are less globular. Mandible more robust than in the related species, and concavity between condyle and angular process not as deep. Teeth as in *Mus cremoriventer*, but slightly larger throughout.

*Measurements*.—Total length, 310 (317);<sup>2</sup> head and body, 125 (146); tail vertebræ, 185 (171); pencil, 5 (8); hind foot, 28.8 (30?); hind foot without claws, 27 (28.5?); ear from meatus, 17 (17); ear from crown, 13.6 (13); skull, greatest length, 35 (34); zygomatic breadth, 16 (15.4); length of nasals, 13 (11.8); depth of rostrum behind incisors, 7 (6); length of incisive foramen, 6.4 (5.6).

*Specimens examined*.—One, the type.

*Remarks*.—While the skull, teeth, and unicolor tail show that this rat is closely related to *Mus cremoriventer*, the conspicuous appearance at the surface of the spines in the fur of back and sides gives the animal a strong superficial resemblance to the members of the *surifer* group. That this peculiarity is not due to moult is shown by the fresh, unabraded condition of the fur. Not only are the soft hairs less abundant than in *Mus cremoriventer*, but the spines are distinctly larger. This difference is most noticeable on the back and sides, but is also apparent on the underparts, particularly in region between and just behind front legs.

#### MUS LUTEOLUS sp. nov.

*Type*.—Adult female (skin and skull), No. 104,276, United States National Museum. Collected on St. Matthew Island, Mergui Archipelago, January 15, 1900, by Dr. W. L. Abbott. Original number, 226.

*Characters*.—A small member of the *rajah-surifer* group, resembling *Mus flavidulus* of Pulo Lankawi, but with tawny element in color distinctly less yellow.

*Color*.—Ground color of back and sides buff, almost exactly similar to that of Ridgway, very uniform throughout, though a little more yellow on shoulders and neck. Back thickly sprinkled with black-tipped spines, but the black is nowhere in excess of the buff,

<sup>1</sup> *Proc. Biol. Soc. Washington*, XIII, pl. v, fig. 2, April 21, 1900.

<sup>2</sup> Measurements in parenthesis are those of the type of *Mus cremoriventer*.

nor is there any tendency toward the formation of a dark dorsal line. Laterally the dark tips become less and less abundant, their color at the same time fading through bluish gray nearly to white, so that near line of demarkation between color of sides and that of underparts the buff is essentially pure. Underparts and inner surface of legs white, distinctly tinged with cream-buff. A well defined whitish patch covers area on each side of muzzle from which whiskers spring. Eye surrounded by a well-defined dark ring.

*Measurements.*—Measurements of type: total length, 360; head and body, 190; tail, 170; hind foot, 37 (35); skull, greatest length, 45; zygomatic breadth, 19.

*Specimens examined.*—Twenty-three (four skulls without skins), all from St. Matthew Island.

*Remarks.*—The series of nineteen skins presents no variation in color worthy of special comment. One specimen has the tail longer than the head and body, but in all the rest the proportions are essentially as in the type.

#### MUS UMBRIDORSUM sp. nov.

*Type.*—Adult male (skin and skull), No. 104,227, United States National Museum. Collected on Loughborough Island, Mergui Archipelago, January 24, 1900, by Dr. W. L. Abbott. Original number, 269.

*Characters.*—Similar to *Mus luteolus*, but ground color above slightly more yellow, and black of back tending to concentrate into a noticeable dorsal streak.

*Color.*—The ground color of back and sides is intermediate between the buff and buff-yellow of Ridgway, though nearer the latter. Black-tipped spines slightly more abundant than in *Mus luteolus*, those of middle of back forming a distinct though not sharply outlined dorsal streak about 10 mm. wide, extending from nape to base of tail. Otherwise as in *Mus luteolus*.

*Measurements.*—Measurements of type: total length, 350; head and body, 180; tail vertebræ, 170; hind foot, 40 (38); skull, greatest length, 42; zygomatic breadth, 18.

*Specimens examined.*—Thirteen (five skulls without skins), all from Loughborough Island.

*Remarks.*—Specimens vary somewhat in the yellowness of the upperparts and in the distinctness of the dark dorsal area, but the series considered as a whole is easily distinguishable from those procured on other islands or on the mainland. In every individual the length of head and body exceeds that of tail.

**MUS BENTINCANUS** sp. nov.

*Type*.—Adult female (skin and skull), No. 104,269, United States National Museum. Collected on Bentinck Island, Mergui Archipelago, March 11, 1900, by Dr. W. L. Abbott. Original number, 348.

*Characters*.—A rather large member of the *rajah-surifer* group, much resembling *Mus butangensis*, but color of back less strongly suffused with yellow.

*Color*.—The color is so similar to that of *Mus umbridorsum* as to need no special description. The black of the back, however, shows very little tendency toward the formation of a dorsal stripe.

*Measurements*.—Measurements of type: total length, 385; head and body, 205; tail, 180; hind foot, 42 (40); skull, greatest length, 47; zygomatic breadth, 22.

*Specimens examined*.—Eight (two skulls without skins), all from Bentinck Island.

*Remarks*.—This race is distinguishable from *Mus butangensis* by its lighter color, and from its relatives of the Mergui Archipelago by its large size combined with the absence of a throat band.

**MUS CASENSIS** sp. nov.

*Type*.—Adult male (skin and skull), No. 104,249, United States National Museum. Collected on Chance Island, Mergui Archipelago, December 28, 1899, by Dr. W. L. Abbott. Original number, 188.

*Characters*.—Similar to *Mus butangensis*, but with well developed throat band.

*Color*.—The color so closely resembles that of *Mus butangensis* as to require no detailed description.<sup>1</sup> As in this form the ground tint above is a yellowish ochraceous-buff, noticeably brighter than that of *Mus bentincanus*. Underparts whitish cream-buff, the throat crossed by a yellowish ochraceous-buff stripe about 30 mm. in width.

*Measurements*.—Measurements of type: head and body, 200; tail imperfect; hind foot, 42 (40); skull, greatest length, 47; zygomatic breadth, 21.

*Specimens examined*.—Seven (two skulls without skins), all from Chance Island.

*Remarks*.—As in the other insular forms of the *Mus surifer* group the tail is shorter than the head and body.<sup>2</sup> In all five specimens

<sup>1</sup> See *Proc. Biol. Soc. Washington*, XIII, p. 190, December 21, 1900.

<sup>2</sup> In an adult male (No. 104,284), with head and body the same length as in the type, the tail measures 178 mm.

the throat band is well developed. One female (No. 104,250), has the belly strongly darkened with gray.

**MUS DOMELICUS** sp. nov.

*Type*.—Adult female (skin and skull), No. 104,257, United States National Museum. Collected on Domel Island, Mergui Archipelago, February 24, 1900, by Dr. W. L. Abbott. Original number, 320.

*Characters*.—Similar to *Mus casensis*, but ground color above not as bright, and throat band less distinct.

*Color*.—As in *Mus casensis* the ground color above is a yellowish ochraceous-buff, but it is so much lighter than in the related form that the difference is readily noticeable when series are compared. Underparts as in *Mus casensis*, except that the throat band is a dull, light ochraceous-buff, which produces no strong contrast with the surrounding parts.

*Measurements*.—Measurements of type: total length, 350; head and body, 200; tail vertebræ, 150; hind foot, 40 (38); skull, greatest length, 49.

*Specimens examined*.—Seven (one extra skull), all from Domel Island.

**MUS PAGENSIS** sp. nov.

*Type*.—Adult male (skin and skull), No. 121,629, United States National Museum. Collected on South Pagi Island, Sumatra, December 23, 1902, by Dr. W. L. Abbott. Original number, 2153.

*Characters*.—A large, dark member of the *rajah-surifer* group, somewhat resembling *Mus catellifer* of Pulo Mansalar, but size greater, tail relatively longer, and collar obsolete or absent.

*Color*.—Type: back and sides ochraceous, the former heavily overlaid with blackish horn-color, the latter nearly clear. The ochraceous area widens considerably at shoulder and extends over outer surface of legs to feet, and also across rump. On hind legs it is darkened by a brownish wash. Top of head like back. Cheeks dirty brownish buff. Feet whitish, shaded with dark brown. Tail distinctly but not conspicuously bicolor to tip, blackish above, whitish below. Underparts and inner surface of legs pale cream-buff.

*Skull and teeth*.—The skull and teeth are larger than those of *Mus catellifer*, but do not differ appreciably in form.

*Measurements*.—Measurements of type: total length, 406; head and body, 216; tail vertebræ, 190; hind foot, 46 (43.6); ear from meatus, 24; ear from crown, 17; width of ear, 15; skull, greatest length, 50.4; basal length, 40; length of nasals, 19; zygomatic breadth, 21; interorbital constriction, 8.

*Specimens examined*.—Eleven, all from the Pagi Islands.

*Remarks*.—While this species is as dark in general coloration as *Mus catellifer*, it is readily distinguishable by its greater size, and by the less development of the brown collar. In six of the specimens the throat is entirely pure white. The five others show traces of a collar, and in two the band is complete though much less noticeable than in the Mansalar rat.

**CHIROPDOMYS NIADIS** sp. nov.

*Type*.—Adult female (skin and skull), No. 121,867, United States National Museum. Collected at Lafau, Nias Island, Sumatra, March 30, 1903, by Dr. W. L. Abbott. Original number, 2413.

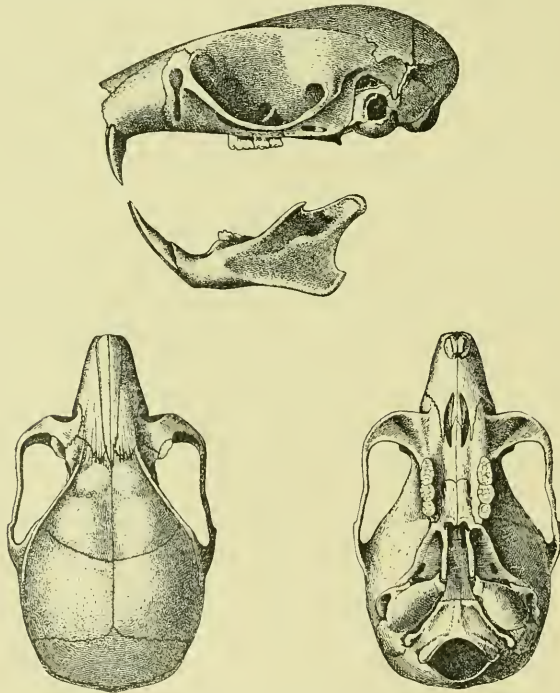


FIG. 1.—Skull of *Chiropodomys niadis* ( $\times 2$ ).

*Characters*.—Size as in *Chiropodomys glirioides*, but color not as dark, and skull with dorsal profile strongly convex.

*Color*.—Upperparts wood-brown, everywhere paler than that of Ridgway, and tinged, particularly on sides and flanks, with drab. On middle of back the blackish hair-tips produce a slight dusky cast.

Underparts white, faintly tinged with cream-buff. Line of demarcation sharp. Tail and ears uniform dark brown. Feet whitish, with dusky cloudings on metapodials. Whiskers black.

*Skull and teeth.*—The skull differs from that of *Chiropodomys glirioides* as described and figured by Sclater<sup>1</sup> in several important details. Most conspicuous among these is the convexity of the dorsal outline. From tip of nasals to middle of frontals the outline is essentially straight, distinctly less convex than in Sclater's figure. From middle of frontals back, however, the convexity is so strong that when the nasals are held in line with those of the figure theinion falls opposite the middle of occipital condyle. Viewed from below the skull differs from that of *C. glirioides* in the less broadened anterior palatine foramina, and narrower, parallel-margined, interpterygoid space. The width of the latter barely equals one-half the length of the anterior palatine foramina, while in *C. glirioides*, as both described and figured, it is considerably more than half. Mandible shorter and deeper than that of *C. glirioides*, the angular process wider and less distinctly marked off from main portion of jaw. Teeth, so far as can be judged from the description and figures, essentially as in *C. glirioides*.

*Measurements.*—Total length, 183; head and body, 81; tail vertebræ, 102; pencil, 4; hind foot, 19 (18); ear from meatus, 14.6; ear from crown, 12; width of ear, 10; skull, greatest length, 24; basal length, 20.4; basilar length, 18.6; zygomatic breadth, 14; least interorbital breadth, 4.8; greatest breadth of braincase above roots of zygomata, 12; diastema, 6.8; length of anterior palatine foramen, 3.6; breadth of both foramina together, 1.8; greatest width of interpterygoid space anteriorly, 1.6; mandible, 14; maxillary toothrow (alveoli), 3.6; mandibular toothrow (alveoli), 3.2.

*Specimens examined.*—One, the type.

*Remarks.*—This species was first recorded by Modigliani in 1889,<sup>2</sup> and has since been mentioned by Thomas.<sup>3</sup> Neither writer, however, appears to have examined the skull. Unless the figures published by Sclater are grossly inaccurate, and there is no reason to suppose that such is the case, the Nias animal is readily distinguishable from *Chiropodomys glirioides*. It needs no special comparison with the Bornean forms.

<sup>1</sup> *Proc. Zool. Soc. London*, 1890, p. 533, pl. XLV, figs. 6a and 6b.

<sup>2</sup> *Ann. Mus. Civ. di Storia Nat. di Genova*, 2d ser., VII, p. 244, 1889.

<sup>3</sup> *Ibid.*, x, p. 942, 1892.

## ATHERURA ZYGOMATICA sp. nov.

(PLATE II, FIGURE 4)

*Type*.—Adult female (skin and skull), No. 112,429, United States National Museum. Collected on Pulo Aor, off coast of Johore, June 6, 1901, by Dr. W. L. Abbott. Original number, 1009.

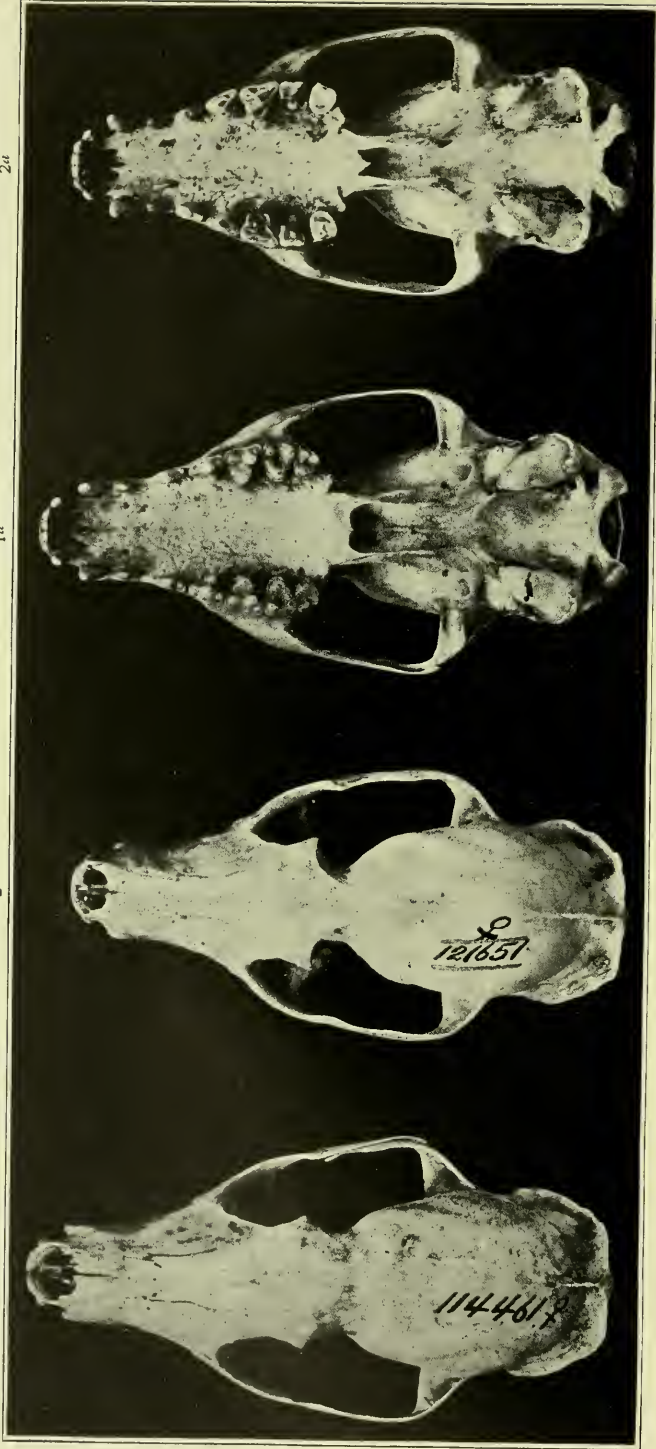
*Characters*.—Like *Atherura macroura*, from Trong, Lower Siam, but color darker and more bluish, and zygoma shorter and deeper.

*Color*.—*Type*: The elements of the color are essentially as in the mainland animal, that is, the quills are deep bluish horn-color, varied with whitish. But the horn-color is more blue and less brown than in the related form; and the whitish areas are less developed, so that the dark predominates everywhere, instead of only on back, head and legs. Underparts, except dull whitish area on chin and another in each axilla, dark drab horn-color, darker and clearer on inner side of hind legs, lighter and speckled with whitish along sides of body. Feet, and bristles on naked portion of tail, horny blackish. Ears and whiskers blackish. Tuft of bristles at end of tail dull whitish horn-color.

*Skull and teeth*.—In general appearance the skull (pl. II, fig. 4) resembles that of *Atherura macroura* (pl. II, fig. 5). Its size, however, is slightly less, and in the form of the lachrymal bone and of the zygoma it appears to differ constantly from the skull of the mainland animal. In *Atherura macroura* the lachrymal is fully 8 mm. in length below rim of orbit, while above it extends forward as a triangle of bone at least 5 mm. long, and is a noticeable feature of the dorsal aspect of the skull. In *A. zygomatica* its length below rim of orbit is usually about 5 mm. (in only one skull out of seven does it exceed 6 mm.), while the forward extension is often obsolete, and never large enough to be more than barely visible when the skull is viewed from above. Zygoma shorter than in *Atherura macroura*, the jugal deeper in proportion to its length, more abruptly concave above, and its lower contour invariably—even in a specimen so young that the posterior molar is not yet in place—broken by a strongly developed concavity beneath posterior jugal suture, this concavity terminating anteriorly on the posterior upper surface of a well-marked tooth-like projection. This character is present in all of the seven skulls of *Atherura zygomatica*, and is barely indicated in the three skulls of *A. macroura* that I have examined. Paroccipital processes broad and stout, not slender and elongate as in the related species. Posterior section of mandible shorter and deeper than in *A. macroura*.







1. *Hemigale haradovichii*, female, No. 114461, Tapanuli Bay, Sumatra. 2. *Hemigale minor*, female (type).

Teeth as in *Atherura macroura*. I can detect no peculiarities in the pattern of enamel folding.

*Measurements.*—External measurements of type: total length, 720; head and body, 520; tail vertebrae, 200; hind foot, 64 (61); ear from meatus, 34; ear from crown, 21; width of ear, 17.

Cranial measurements of type: greatest length, 93 (99);<sup>1</sup> basal length, 82 (87); basilar length, 77 (80); length of nasals, 26 (25); greatest breadth of both nasals together, 14 (15); diastema, 28 (28.4); zygomatic breadth, 45.4 (47.6); least interorbital breadth, 26 (28.6); length of zygoma from posterior rim of antorbital foramen, 29 (31); depth of zygoma at anterior jugal suture, 8.6 (8); mandible, 58 (61); maxillary tooththrow (alveoli), 17 (17.6); mandibular tooththrow (alveoli), 17.8 (19).

*Specimens examined.*—Seven, all from Pulo Aor.

#### HEMIGALE MINOR sp. nov.

(PLATE III, FIGURE 2)

*Type.*—Adult female (skin and skull), No. 121,651, United States National Museum. Collected on South Pagi Island, Sumatra, December 27, 1902, by Dr. W. L. Abbott. Original number, 2173.

*Characters.*—Like *Hemigale hardwickii* Gray, but smaller and darker.

*Color.*—Type: upperparts and outer surface of legs a buffy gray, much less yellow than that of *Hemigale hardwickii*. The exact shade is not easy to describe, but it is a mixture of broccoli-brown or pale isabella-color and grayish white, the former beneath the surface, the latter at the tips of the hairs. Dark markings clear black, exactly as in *Hemigale hardwickii* except that they are all wider and those of head and neck are ill-defined, owing to their tendency to spread over the intervening gray. Underparts light brownish buff, or pale, yellowish isabella-color, the tips of most of the hairs grayish white, these most noticeable on throat and forepart of chest. Inner surface of legs an indefinite yellowish gray. Feet broccoli-brown washed with buffy gray. Tail blackish brown except for two grayish rings at base and a grayish ventral area extending about to middle. Ears dusky brownish outside, dull buffy gray inside.

*Skull and teeth.*—Except for its smaller size the skull (pl. III, fig. 2) closely resembles that of *Hemigale hardwickii* (pl. III, fig. 1) in general appearance. The audital bullae are, however, less elevated above surface of basioccipital (when skull is held upside

<sup>1</sup> Measurements in parenthesis are those of an adult female *Atherura macroura* from Trong, Lower Siam (No. 84,433).

down) and the interpterygoid space is much narrower in proportion to its length. The constriction behind postorbital processes appears to be deeper and better defined than in the larger animal, but this character may not be constant. Teeth as in *Hemigale hardwickii* but smaller.

*Measurements.*—External measurements of type: total length, 760; head and body, 480; tail vertebræ, 280; hind foot, 67 (64); ear from meatus, 30; ear from crown, 26; width of ear, 19. External measurements of adult male (No. 121,650) from the type locality: total length, 715; head and body, 465; tail vertebræ, 250; hind foot, 65 (63).

Cranial measurements of type: greatest length, 95 (99);<sup>1</sup> basal length, 91.4 (96); basilar length, 87 (91); median palatal length, 50 (52); breadth of palate between anterior molars, 16.8 (16); length of interpterygoid space, 15.8 (15.4); width of interpterygoid space at middle, 6 (7.8); constriction in front of postorbital processes, 19 (18.4); constriction behind postorbital processes, 12.4 (17); zygomatic breadth, 45 (47); mastoid breadth, 31 (32); breadth of braincase above roots of zygomata, 29.8 (31); mandible, 66.4 (70); maxillary toothrow exclusive of incisors (alveoli), 37 (39); mandibular toothrow exclusive of incisors (alveoli), 40 (42).

*Specimens examined.*—Six, all from South Pagi Island.

*Remarks.*—This species is well characterized by the dark color of its head and the indistinctness of the black markings in this region. The pattern is exactly the same as that of *Hemigale hardwickii*, but the gray is so dull and the black so diffused that the longitudinal stripes are no longer a conspicuous feature of the animal's markings. The dark cross-bands on the back average wider than in the related species but their outlines are nearly as well defined. The series presents no variation worthy of note.

#### PARADOXURUS LIGNICOLOR sp. nov.

(PLATE IV, FIGURE 1, AND PLATE V, FIGURE 1)

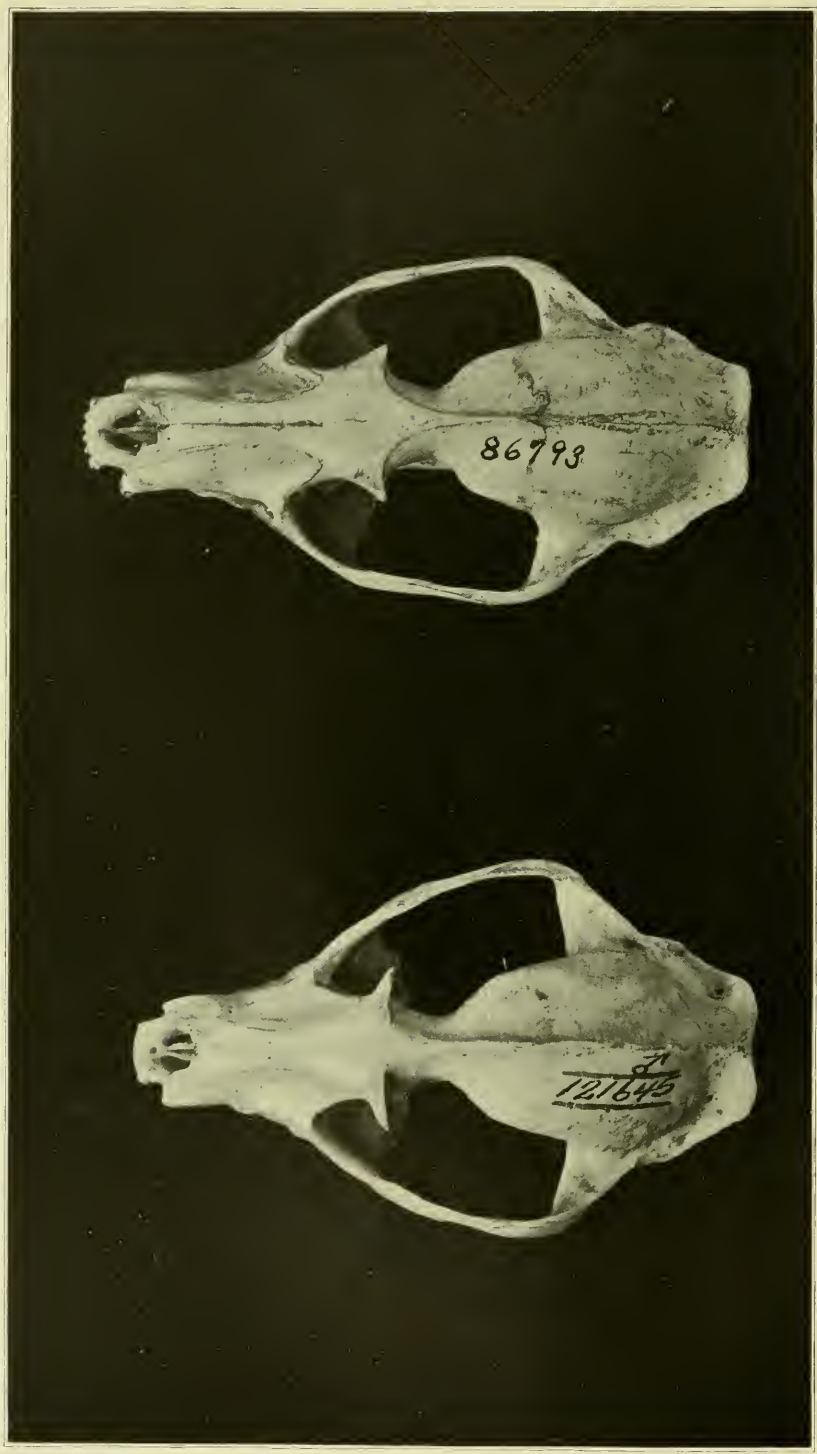
*Type.*—Adult male (skin and skull), No. 121,645, United States National Museum. Collected on North Pagi Island, Sumatra, November 19, 1902, by Dr. W. L. Abbott. Original number, 2068.

*Characters.*—Not as large as *Paradoxurus hermaphroditus*, but general form the same. Color yellowish brown with no dark markings; tail lighter than body. Teeth relatively larger than those of

<sup>1</sup> Measurements in parenthesis are those of an adult female *Hemigale hardwickii* (No. 114,461), not as old as the type of *H. minor*, from Tapanuli Bay, Sumatra.



2



1. *Paradoxurus lignicolor*, male (type). 2. *Paradoxurus hermaphroditus*, male, No. 86,793, Trong, Lower Siam.

*P. hermaphroditus*, but not essentially different in form. Nasals flat posteriorly.

*Color*.—Entire animal wood-brown, the belly and tail tinged with buff, the back somewhat lightened by the indistinct, grayish, sub-terminal annulations of the hairs. Dorsal line from crown to base of tail clouded by a wash of mummy-brown, most distinct on head and neck. Feet and outer surface of front legs tinged with broccoli-brown. The fur of the upperparts, chin, and throat is drab at base, that of belly and tail buffy throughout. Everywhere the hairs have a distinct silvery gloss, but this is especially noticeable on distal half of tail. Whiskers light wood-brown.

*Skull and teeth*.—The skull (pl. iv, fig. 1, and pl. v, fig. 1) closely resembles that of *Paradoxurus hermaphroditus* (pl. iv, fig. 2, and pl. v, fig. 2), but the interpterygoid space is narrower and there is scarcely a trace of the longitudinal groove involving the region between upper rims of maxillaries. Teeth essentially as in *P. hermaphroditus*, but inner lobe of upper sectorial longer, and set at a somewhat different angle, so that the width of the palate is considerably reduced.

*Measurements*.—External measurements of type: total length, 845; head and body, 485; tail vertebræ, 360; hind foot, 77 (75); ear from meatus, 33; ear from head, 19.6; width of ear, 25.

Cranial measurements of type: greatest length, 104 (112);<sup>1</sup> basal length, 99 (107); basilar length, 94.6 (102); median palatal length, 47 (50); breadth of palate between sectorials, 14 (18); breadth of palate between front molars, 19 (21); length of interpterygoid space, 20 (24); breadth of interpterygoid space at middle, 8.6 (10.2); constriction in front of postorbital processes, 17 (19); constriction behind postorbital processes, 10.4 (11); zygomatic breadth, 62 (58); mastoid breadth, 38 (38); breadth of braincase above roots of zygomata, 32 (33); mandible, 78 (81); maxillary tooththrow, exclusive of incisors (alveoli), 39 (41); greatest diameter of upper sectorial, 10.2 (10.2); mandibular tooththrow exclusive of incisors (alveoli), 44 (41).

*Specimens examined*.—Two, the type, and the skull of an adult female, the latter from South Pagi Island.

*Remarks*.—This well characterized species is probably most closely allied to *Paradoxurus hermaphroditus*, though in color it undoubtedly more nearly resembles *P. aureus*, an animal which I have not seen. It is apparently of about the same size as the Ceylonese musang.

<sup>1</sup> Measurements in parenthesis are those of an adult male *Paradoxurus hermaphroditus* from Trong, Lower Siam (No. 86,793).

and the teeth of the two animals, to judge by Blanford's description of *P. aureus*, have certain peculiarities in common. Dr. Abbott writes that the female exactly resembled the male in color.

**GALEOPITHECUS PUMILUS** sp. nov.

(PLATE VI, FIGURE 3)

1900. *Galeopithecus volans* MILLER, Proc. Biol. Soc. Washington, XIII, p. 193, December 21, 1900. Not *Lemur volans* Linnæus.

*Type*.—Adult male (skin and skull), No. 104,448, United States National Museum. Collected on Pulo Adang, Butang Islands, December 17, 1899, by Dr. W. L. Abbott. Original number, 165.

*Characters*.—Like *Galeopithecus volans* from the Malay Peninsula, but much smaller. Skull with relatively shorter rostrum and broader palate than in the mainland animal.

*Color*.—Type: entire dorsal surface an intimate blending of smoke-gray, blackish brown, and isabella-color, the gray clear and pale on back of neck and sides of head, tinged with isabella-color on posterior half of back, the brown predominating on legs, feet, and greater part of membranes, the isabella-color most noticeable on crown, along edge of principal membrane, and on distal half of uropatagium. Except for the nearly clear gray area on neck and cheeks the whole upper surface of the body is so mottled and clouded that the exact color is very difficult to describe. A few small flecks of nearly pure white may be detected on posterior edge of thigh. Underparts isabella-color, rather darker than that of Ridgway on throat, chest, and belly, fading toward ochraceous-buff on under side of membranes and limbs.

*Skull and teeth*.—As compared with the skull of an adult male *Galeopithecus volans* (pl. VII, fig. 2; pl. VIII, fig. 2, and pl. IX, fig. 2) from the Rumpin River, Pahang, that of *Galeopithecus pumilus* (pl. VI, fig. 3) is conspicuously smaller, the rostrum is relatively shorter and the palate broader. In the larger animal the least distance from orbit to anterior nares equals that between outer edges of anterior molars, while in *Galeopithecus pumilus* it is equal only to that from outer edge of one molar to inner edge of the opposite tooth. The supraorbital processes are less developed in the smaller animal, in which the greatest width of the process is scarcely more than one-half that of the narrowest flat portion of the interorbital region, instead of nearly equal to the entire width of this area as in the larger species. Braincase shorter than that of *Galeopithecus volans*, and occipital portion less distinctly outlined when skull is viewed from the side.





1



2



1. *Paradoxurus lignicolor*, male (type). 2. *Paradoxurus heru aphroditus*, male, No. 86,793. Trong, Lower Siam.

The teeth are essentially like those of *Galeopithecus volans*, due allowance being made for their smaller size.

*Measurements.*—External measurements of type: total length, 490 (585);<sup>1</sup> head and body, 305 (365); tail vertebræ, 185 (220); hind foot, 55 (69); hind foot without claws, 49 (62); front foot, 62 (77); front foot without claws, 55 (71); ear from meatus, 16 (16); ear from crown, 13 (13); width of ear, 13 (13.4).

Cranial measurements of type: greatest length, 61 (70); basal length, 58 (65); basilar length, 54 (61); lateral palatal length,<sup>2</sup> 27 (32); palatal width at front of first incisor, 11.6 (13.4); palatal width at space between canine and first premolar, 19 (18); distance between inner edge of posterior molars (alveoli), 14, (15.6); least distance from orbit to anterior nares, 19 (23.4); zygomatic breadth, 38.6 (39.6); greatest orbital breadth, 40 (45); least interorbital breadth, 16 (20); breadth of braincase above roots of zygomata, 24 (25); mastoid breadth, 29 (30); greatest depth of braincase, 17 (20); occipital depth, 13.8 (15); mandible, 43 (50); depth of mandible between canine and first premolar, 5.8 (5.6); depth of mandible through coronoid process, 19.6 (21); maxillary toothrow (alveoli), 29 (34); mandibular toothrow (alveoli), 30.2 (35).

*Specimens examined.*—Two, both from Pulo Adang.

*Remarks.*—This small *Galeopithecus* is so readily distinguishable from the peninsular animal, which for the present may be assumed to represent true *volans*, that no further comparison is necessary. From *Galeopithecus temminckii* as figured by Waterhouse it differs in its smaller size, less wide palate, and much smaller teeth.

#### GALEOPITHECUS AORIS sp. nov.

*Type.*—Adult female (skin and skull), No. 112,428, United States National Museum. Collected on Pulo Aor, off coast of Johore, June 8, 1901, by Dr. W. L. Abbott. Original number, 1028.

*Characters.*—Similar to *Galeopithecus pumilus* but not as small, palate relatively not as broad, and upper canine, lower canine, and first premolar much larger.

*Color.*—The type is similar to the type of *Galeopithecus pumilus* except that the wash of isabella-color is less distinct on feet and outer edge of membranes, and the entire back is tinged with whitish cream-buff. A pale buffy spot on each shoulder and hip. A

<sup>1</sup> Measurements in parenthesis are those of an adult male *Galeopithecus volans* from the Rumpin River, Pahang (No. 115,493).

<sup>2</sup> From tip of premaxillary to front of interpterygoid space.

young male (No. 112,427, June 5, 1901) almost exactly resembles the type of *Galeopithecus pumilus*.

*Skull and teeth*.—The skull of the female is about as large as that of the male of *Galeopithecus volans* from the mainland. In form it more closely resembles the skull of the peninsular animal than it does the short broad skull of *Galeopithecus pumilus*. Palate and rostrum rather wider than in *Galeopithecus volans*, but not as wide as in *G. pumilus*. Teeth essentially as in the related species, but canines, both above and below, and first lower premolar relatively larger, particularly in the male.

*Measurements*.—External measurements of type: total length, 625 (690);<sup>1</sup> head and body, 385 (405); tail vertebræ, 240 (285); hind foot, 60 (73); hind foot without claws, 54 (65); front foot, 70 (83); front foot without claws, 63 (75); ear from meatus, 16 (22); ear from crown, 13 (18); width of ear, 12 (17).

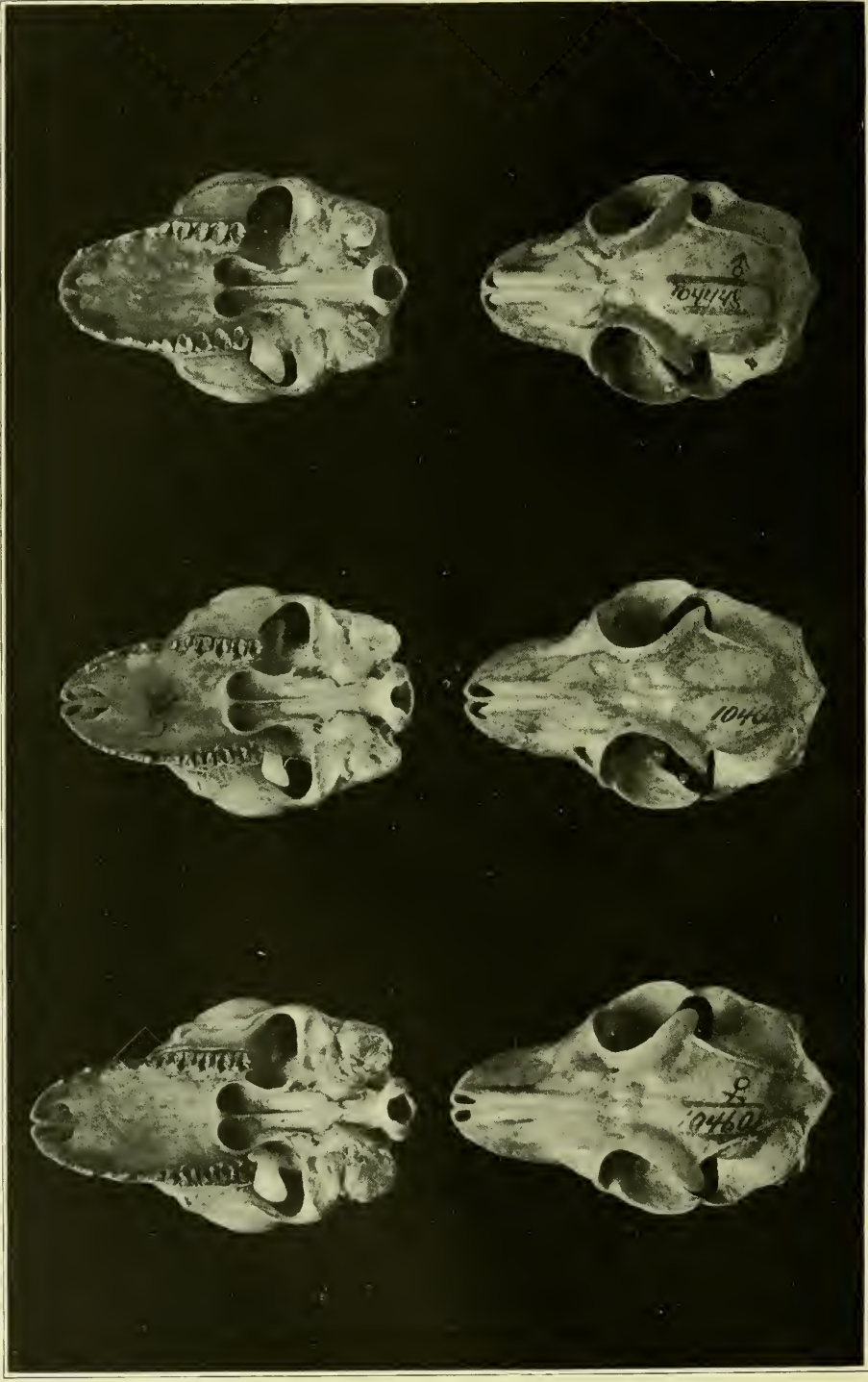
Cranial measurements of type: greatest length, 67 (77.6); basal length, 63 (72.4); basilar length, 58 (68); lateral palatal length, 30.4 (37); palatal width at front of first incisor, 12.4 (15); palatal width at space between canine and first premolar, 20.4 (23); distance between inner edge of posterior molars (alveoli), 15 (17); least distance from orbit to anterior nares, 23 (28); zygomatic breadth, 40 (47.6); depth of zygoma, 4 (6); greatest orbital length, 42 (50); least interorbital breadth, 17.4 (22.6); breadth of braincase above roots of zygomata, 25 (26); mastoid breadth, 30 (36.4); greatest depth of braincase, 17.8 (19); occipital depth, 15 (18); mandible, 50 (57); depth of mandible between canine and first premolar, 6.6 (7); depth of mandible through coronoid process, 20.4 (25.6); maxillary tooththrow (alveoli), 31.6 (37); mandibular tooththrow (alveoli), 33.4 (39).

*Specimens examined*.—Two, both from Pulo Aor.

*Remarks*.—The type is the lightest colored *Galeopithecus* that I have seen, but whether this character is anything more than an individual peculiarity cannot now be determined. The male, so young that the permanent dentition is not fully in place, very closely resembles the type of *Galeopithecus pumilus*, but is not as small. Its measurements are: total length, 530; head and body, 340; tail vertebræ, 190; hind foot, 56 (50.4); front foot, 61 (56); skull, greatest length, 60; zygomatic breadth, 37.

<sup>1</sup> Measurements in parenthesis are those of an adult female *Galeopithecus volans* from Trong, Lower Siam (No. 84,420).





1. *Galeopithecus gracilis*, female (type). 2. *Galeopithecus gracilis*, male, No. 104602, Sirhassen Island, South Natunas. 3. *Galeopithecus puntilus*, male (type).

**GALEOPITHECUS GRACILIS** sp. nov.

(PLATE VI, FIGURE 2)

1901. *Galeopithecus volans* MILLER, Proc. Washington Acad. Sci., March 26, 1901. Part, specimens from Sirhassen Island. Not *Lemur volans* Linnaeus.

*Type*.—Adult female (skin and skull), No. 104,601, United States National Museum. Collected on Sirhassen Island, South Natunas, June 7, 1900, by Dr. W. L. Abbott. Original number, 461.

*Characters*.—Similar to *Galeopithecus pumilus* and *G. aoris* but not as small. Skull more elongate than in the related species, and with much narrower palate.

*Color*.—The color so closely resembles that of the related species as to require no detailed description. Both specimens are in the gray pelage.

*Skull and teeth*.—The skull (pl. VI, fig. 2) is slightly longer than that of *Galeopithecus aoris*, but the width is distinctly less. This is particularly noticeable in the rostral and lachrymal regions. On the other hand, the zygoma is shorter and broader (deeper) than in the related species. Palate narrower than in any other known member of the genus. The teeth are rather larger than those of *Galeopithecus aoris*, but I can detect no tangible peculiarities in form.

*Measurements*.—External measurements of type: total length, 605; head and body, 405; tail vertebræ, 200; hind foot, 62 (59); front foot, 73 (67); ear from meatus, 18; ear from crown, 14; width of ear, 14. External measurements of adult male from the type locality (No. 104,600): total length, 410; head and body, 300; tail vertebræ, 110; hind foot, 62.6 (56); front foot, 67 (60); ear from meatus, 14; ear from crown, 12.6; width of ear, 11.

Cranial measurements of type: greatest length, 68; basal length, 65; basilar length, 61; lateral palatal length, 32.4; palatal width at front of first incisor, 13; palatal width at space between canine and first premolar, 20; distance between inner edge of posterior molars (alveoli), 14.6; least distance from orbit to anterior nares, 24; zygomatic breadth, 38.4; depth of zygoma, 5; greatest orbital breadth, 40.2; least interorbital breadth, 17; breadth of braincase above roots of zygomata, 21.6; mastoid breadth, 31; greatest depth of braincase, 17; occipital depth, 13.4; mandible, 49.6; depth of mandible between canine and first premolar, 6; depth of mandible through coronoid process, 20.4; maxillary toothrow (alveoli), 33; mandibular toothrow (alveoli), 34.

Cranial measurements of adult male from the type locality (No. 104,600): greatest length, 64; basal length, 61; basilar length, 57;

lateral palatal length, 29.6; palatal width at space between canine and first premolar, 19.6; zygomatic breadth, 37; depth of zygoma, 5; mandible, 44.8; maxillary tooththrow (alveoli), 30.6; mandibular tooththrow (alveoli), 31.

*Specimens examined*.—Two, both from Sirhassen Island.

**GALEOPITHECUS NATUNÆ** sp. nov.

1901. *Galeopithecus volans* MILLER, Proc. Washington Acad. Sci., III, p. 134, March 26, 1901. Part, specimen from Bunguran Island. Not *Lemur volans* Linnæus.

*Type*.—Adult female (skin and skull), No. 104,602, United States National Museum. Collected on Bunguran Island, North Natunas, July 16, 1900, by Dr. W. L. Abbott. Original number, 573.

*Characters*.—Intermediate in size between the large and small members of the genus. Skull and teeth essentially as in *Galeopithecus volans* but distinctly smaller. Color as in the related species.

*Color*.—The color shows no tangible differences from that of the species just described. The specimen is in the gray phase.

*Skull and teeth*.—The skull and teeth are very similar to those of *Galeopithecus volans* from the Malay Peninsula, but are readily distinguishable by their smaller size. In the type the lachrymal region is considerably swollen so that the rostrum is less sharply marked off from the orbit than in *Galeopithecus volans*, a character which may prove to be individual. Palate slightly narrower than that of *Galeopithecus volans*, but not closely approaching the form characteristic of the Sirhassen animal. The teeth show no tangible peculiarities.

*Measurements*.—External measurements of type: total length, 660; head and body, 405; tail vertebræ, 255; hind foot, 70 (64); front foot, 83 (77); ear from meatus, 17; ear from crown, 16; width of ear, 12.6.

Cranial measurements of type: greatest length, 71; basal length, 67.6; basilar length, 63; lateral palatal length, 33; palatal width at front of first incisor, 14; palatal width at space between canine and first premolar, 22; distance between inner edge of posterior molars (alveoli), 14.8; least distance from orbit to anterior nares, 26.4; zygomatic breadth, 41.8; depth of zygoma, 5.4; greatest orbital breadth, 44.4; least interorbital breadth, 17.6; breadth of braincase above roots of zygomata, 25.4; mastoid breadth, 33.6; greatest depth of braincase, 19; occipital depth, 15.4; mandible, 51; depth of mandible between canine and first premolar, 6.8; depth of mandible through coronoid process, 22.6; maxillary tooththrow (alveoli), 34.6; mandibular tooththrow (alveoli), 36.





1. *Galeopithecus volans*, female, No. 84,420. Trong, Lower Siam. 2. *Galeopithecus volans*, male, No. 115,403, Rumpin River, Pahang. 3. *Galeopithecus saturatus*, female (type). 4. *Galeopithecus saturatus*, male, No. 121,747, Tana Bala, Batu Islands.



*Specimens examined*.—One, the type.

*Remarks*.—Although represented by one specimen only, this species is undoubtedly distinct from the *Galeopithecus volans* of the Malay Peninsula and from the form inhabiting Sirhassen Island. It appears to be more closely allied to the former, a fact in harmony with the relationship of other Bunguran mammals, notably the giant squirrels.

**GALEOPITHECUS SATURATUS** sp. nov.

(PLATE VII, FIGURES 3 AND 4; PLATE VIII, FIGURES 3 AND 4; PLATE IX, FIGURES 3 AND 4)

*Type*.—Adult female (skin and skull), No. 121,750, United States National Museum. Collected on Tana Bala, Batu Islands, Sumatra, February 12, 1903, by Dr. W. L. Abbott. Original number, 2278.

*Characters*.—Slightly larger than *Galeopithecus volans*, and sexual difference in size less noticeable than in the other known species. First upper incisor usually with four cusps. Color very dark, the light phase not unlike the dark phase of *Galeopithecus volans*.

*Color*.—*Light phase* (type specimen): dorsal surface mostly ochraceous-buff and seal-brown, the former predominating on body, hind legs, and interfemoral membrane, the latter nearly clear on forearms. Neck washed with gray, shoulders and back with cream-buff. Face suffused with dark brown. The colors are everywhere indescribably blended. On each hip there is a conspicuous buffy white spot, and two similar but smaller spots occur behind each shoulder. The feet and edges of the principal membranes are speckled with grayish white dots. Dark area of forearm intensified by about six conspicuous buffy white spots 3–8 mm. in length and about 2 mm. wide. Under surface of body drab washed with wood-brown. Under surface of legs and membranes tawny clay-color considerably lighter than that of Ridgway. *Dark phase* (adult male, No. 121,749); general color above seal-brown, faintly grizzled with russet on interfemoral membrane, lumbar region, and sides of back. On front legs and feet and over most of the membranes there is a noticeable sprinkling of whitish hairs, these most conspicuous on forearm. Neck dull, grizzled wood-brown. Head blackish, sprinkled with silvery white hairs. Hip spots indicated by a few tufts of creamy white. White spots on shoulders and forearms obsolete. Underparts as in the light phase, but wood-brown and drab rather darker, and interfemoral membrane heavily washed with an indefinite dark brown. *Red phase* (adult male, No. 121,853): entire upperparts bright cinnamon-rufous, the hairs fading to orange-buff beneath the surface of the fur. Neck slightly grizzled with wood-

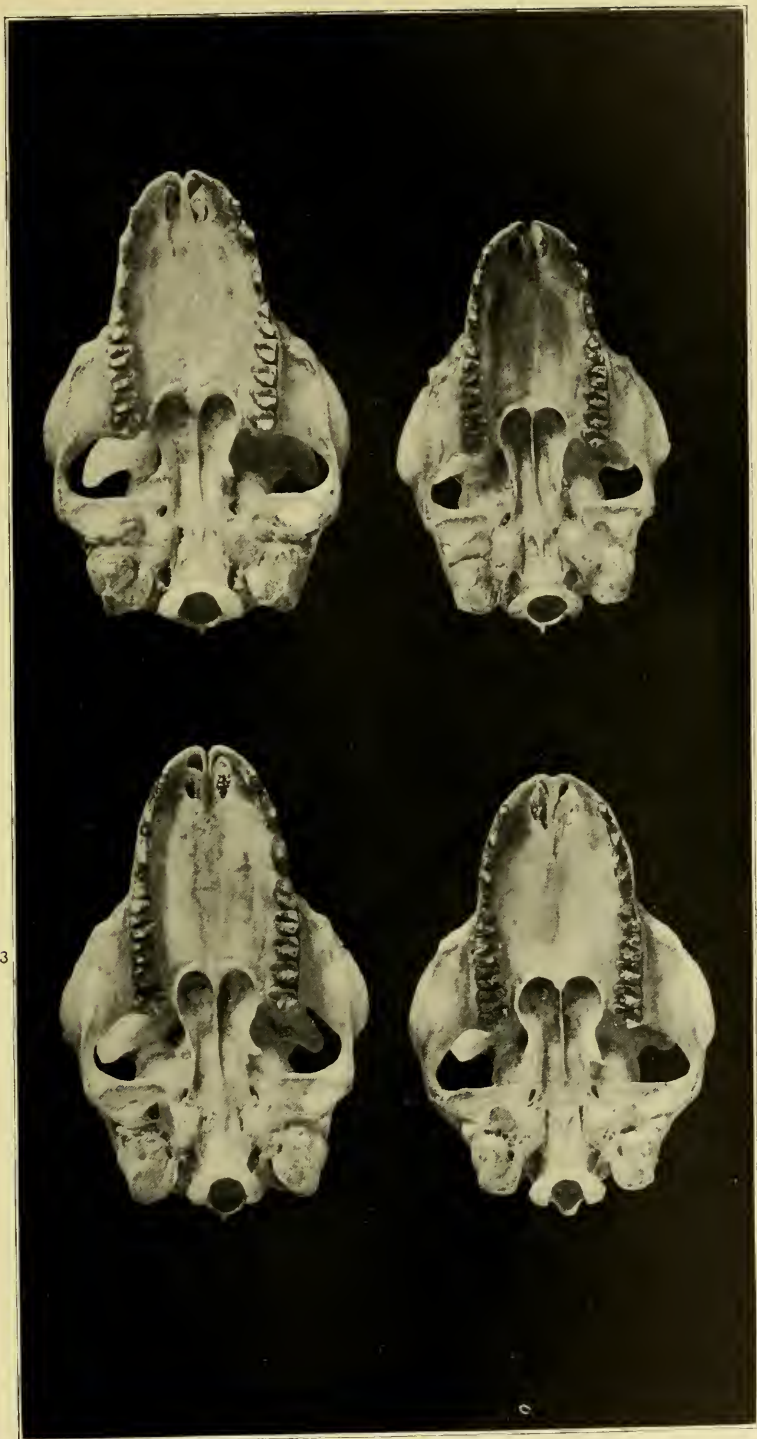
brown. A slight burnt-sienna wash on shoulders. Head, face, and chin burnt-sienna. Underparts essentially as in the other phases, but everywhere tinged with rufous.

*Skull and teeth.*—In general form the skull (pl. VII, figs. 3 and 4; pl. VIII, figs. 3 and 4; pl. IX, figs. 3 and 4) closely resembles that of *Galeopithecus volans* (pl. VII, figs. 1 and 2; pl. VIII, figs. 1 and 2; pl. IX, figs. 1 and 2). In fact, when skulls of females are compared the only tangible difference appears to be in the form of the basioccipital and foramen magnum. In *Galeopithecus saturatus* this bone is narrower than in the mainland animal, and the occipital condyles are set at a less distinct angle. Consequently the foramen magnum is more nearly of the same width above and below, and the whole bony structure surrounding it stands out as more noticeably tubular. This character is equally noticeable in the skull of the male, which is further distinguished by its considerably greater size (see measurements of *Galeopithecus volans* under *G. pumilus*, p. 47). The teeth resemble those of *Galeopithecus volans*, but are more robust, and the first upper incisor is conspicuously larger. In four of the five skulls this tooth has four well developed cusps, while three is the usual number in the other species.

*Measurements.*—External measurements of type: total length, 725; head and body, 459; tail vertebræ, 266; hind foot, 76 (68); front foot, 85 (77); ear from meatus, 20; ear from crown, 16; width of ear, 14. External measurements of adult male from the type locality (No. 121,747): total length, 653; head and body, 403; tail vertebræ, 250; hind foot, 70 (63); front foot, 83 (74).

Cranial measurements of type: greatest length, 78; basal length, 74; basilar length, 69; lateral palatal length, 36.8; palatal width at front of first incisor, 14.4; palatal width at space between canine and first premolar, 23.6; distance between inner edge of posterior molars (alveoli), 16.8; least distance from orbit to anterior nares, 28; zygomatic breadth, 45; greatest orbital breadth, 51; least inter-orbital breadth, 22; breadth of braincase above roots of zygomata, 27; mastoid breadth, 34.6; greatest depth of braincase, 20; occipital depth, 16.6; mandible, 54; depth of mandible between canine and first premolar, 6.6; depth of mandible through coronoid process, 23; maxillary toothrow (alveoli), 38; mandibular toothrow (alveoli), 37.

Cranial measurements of adult male (No. 121,747): greatest length, 73; basal length, 70; basilar length, 65.6; lateral palatal length, 34; palatal width at space between canine and first premolar, 23; zygomatic breadth, 46; mandible, 55; maxillary toothrow (alveoli), 37; mandibular toothrow (alveoli), 37.



1. *Galeopithecus volans*, female, No. 84,420, Trong, Lower Siam. 2. *Galeopithecus volans*, male, No. 115,493, Rumpin River, Pahang. 3. *Galeopithecus saturatus*, female (type). 4. *Galeopithecus saturatus*, male, No. 121,747, Tana Bala, Batu Islands.



*Specimens examined.*—Six, all but one from Tana Bala, the latter from Pulo Pinie.

*Remarks.*—Of the six skins two, both males, are in the dark pelage, one male is in the red phase, and the one female, the type, is in the gray coat. The two others, both males, are in a stage intermediate between the red and dark phases. Due allowance being made for the three phases, the species is not unusually variable in color. Specimens in the dark or red pelages are very different from *Galeopithecus volans*, but those in the gray phase might readily be mistaken for the mainland animal in dark coat. But whatever the characters of the skin, the species is always recognizable by the relatively slight difference in the size of the two sexes, and by the large anterior upper tooth.

#### GALEOPITHECUS TUANCUS sp. nov.

1901. *Galeopithecus volans* MILLER, Proc. U. S. Nat. Mus., xxvi, p. 471, February 3, 1903. Not *Lemur volans* Linnæus.

*Type.*—Adult female (skin and skull), No. 114,375, United States National Museum. Collected on Pulo Tuangku, Banjak Islands, Sumatra, January 22, 1902, by Dr. W. L. Abbott. Original number, 1454.

*Characters.*—Color essentially as in *Galeopithecus saturatus*, but gray phase apparently lighter. Size much less than that of the Batu animal.

*Color.*—*Light phase* (type specimen): The animal was evidently moulting when killed, as two pelages are represented; a thin, abraded, grayer coat on limbs, head, neck, and sides, and a fresh, more brown coat on back. The former closely resembles the ordinary gray phase of *Galeopithecus volans*, and calls for no special comment. The latter is essentially like the back in the type specimen of *Galeopithecus saturatus*, but the colors are not as bright and well contrasted. Underparts as in the type of *G. saturatus*. *Dark phase* (immature<sup>1</sup> male, No. 114,376): like corresponding pelage of *Galeopithecus saturatus*, except that the back is more suffused with russet, and the neck is distinctly tinged with gray.

*Skull and teeth.*—The skull is much smaller than that of *Galeopithecus saturatus*, that of the female closely corresponding with that of the female *G. aoris* in size. The skull of the male, however, is decidedly larger than in the male *G. aoris* of exactly comparable age. Teeth as in *Galeopithecus aoris*, except that the first

<sup>1</sup> Apparently full grown, but permanent dentition not fully in place.

upper incisor is larger and in the permanent dentition shows a distinct trace of a fourth cusp.

*Measurements.*—External measurements of type: total length, 640; head and body, 385; tail vertebræ, 235; hind foot, 65 (59); front foot, 78 (71); ear from meatus, 18; ear from crown, 16; width of ear, 13. External measurements of immature male (No. 114,376): total length, 550; head and body, 335; tail vertebræ, 215; hind foot, 63 (57); front foot, 68 (61).

Cranial measurements of type: greatest length, 69; basal length, 65.4; basilar length, 61; lateral palatal length, 32; palatal width at front of first incisor, 13; palatal width at space between canine and first premolar, 20.4; distance between inner edge of posterior molars (alveoli), 16; least distance from orbit to anterior nares, 24.2; zygomatic breadth, 41; greatest orbital breadth, 45; least interorbital breadth, 19.4; breadth of braincase above roots of zygomata, 24; mastoid breadth, 28.6; greatest depth of braincase, 19; occipital depth, 15; mandible, 49; depth of mandible between canine and first premolar, 6.6; depth of mandible through coronoid process, 21; maxillary toothrow (alveoli), 33; mandibular toothrow (alveoli), 33.6.

Cranial measurements of immature male (No. 114,376) from the type locality: greatest length, 66; basal length, 63; basilar length, 58; lateral palatal length, 30.6; palatal width at space between canine and first premolar, 19.6; zygomatic breadth, 39; mandible, 48.4; maxillary toothrow (alveoli), 30.6; mandibular toothrow (alveoli), 32.4.

*Specimens examined.*—Two, both from Pulo Tuangku.

#### TUPAIA CASTANEA sp. nov.

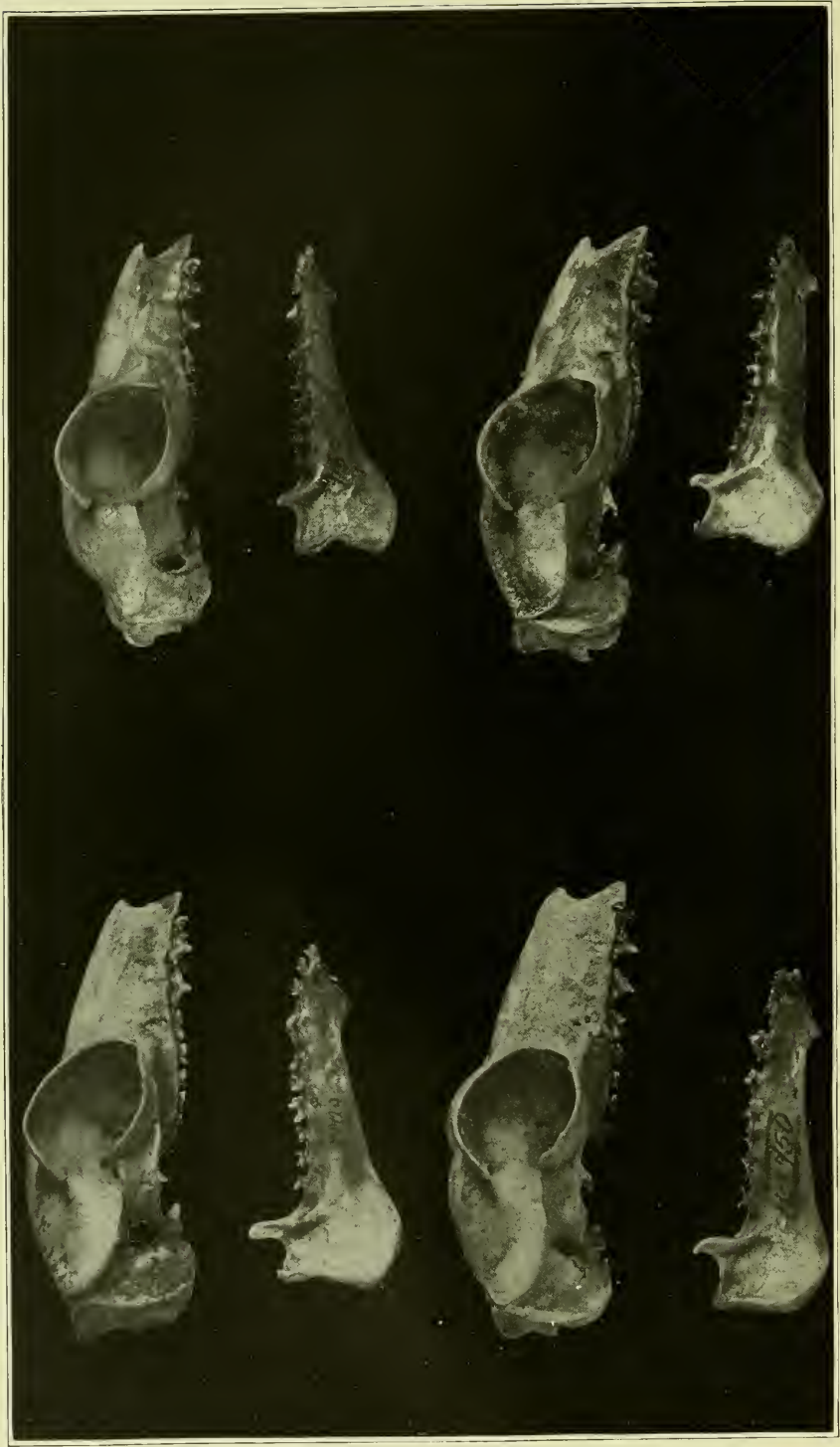
*Type.*—Adult female (skin and skull), No. 115,608, United States National Museum. Collected on Pulo Bintang, Rhio Archipelago, August 11, 1902, by Dr. W. L. Abbott. Original number, 1872.

*Characters.*—Similar to *Tupaia splendidula* but larger and darker; underparts clear tawny-ochraceous.

*Color.*—Upperparts a fine, close mixture of black and ferruginous, the general effect slightly more red than the chestnut of Ridgway, though in certain lights appearing almost black. The hairs are everywhere very glossy. On occiput and forehead the chestnut fades rather abruptly into the light grizzled brown of face and cheeks. The pale element of this grizzle is ochraceous-buff, the dark element an indefinite blackish brown. The former is a little in excess. Outer surface of hind legs like back, outer surface of







1. *Galeopithecus volans*, female, No. 84,420, Trong, Lower Siam. 2. *Galeopithecus volans*, male, No. 115,943, Ramin River, Pahang. 3. *Galeopithecus saturatus*, female (type). 4. *Galeopithecus saturatus*, male, No. 121,747, Tana Bala, Batu Islands

front legs like face. Underparts, shoulder stripes, and inner surface of legs, clear tawny-ochraceous, the hairs on the chest and throat slaty at base. Feet and ears dusky, the former distinctly darker than legs. Tail light ferruginous, heavily clouded above with blackish brown at base and near tip. The second specimen shows no marked variation from the type.

*Skull and teeth.*—The skull and teeth closely resemble those of *Tupaia splendidula*, but are distinctly larger throughout.

*Measurements.*—External measurements of type: total length, 345; head and body, 200; tail vertebræ, 145; hind foot, 44 (42). External measurements of adult male from type locality: total length, 360; head and body, 210; tail vertebræ, 150; hind foot, 46 (44).

Cranial measurements of type: greatest length, 53 (50);<sup>1</sup> basal length, 49 (—); basilar length, 46 (—); palatal length, 28 (26); diastema, 3.4 (3.4); breadth of palate at middle of diastema, 5.6 (5.6); breadth of palate between middle molars, 10 (9); least inter-orbital breadth, 15.6 (14.8); zygomatic breadth, 25.4 (25); breadth of braincase above roots of zygomata, 20 (19); maxillary toothrow exclusive of incisors (alveoli), 19 (19); mandible, 35 (34); mandibular toothrow exclusive of incisors (alveoli), 19.4 (19).

*Specimens examined.*—Two, both from Bintang Island.

*Remarks.*—The discovery of this treeshrew is of unusual interest, as it greatly extends the range of the group to which the species belongs. Hitherto three members have been known, *Tupaia splendidula* Gray from Bunguran Island, *T. lucida* (Thomas) from Pulo Laut, North Natunas, and *T. chrysomalla* Miller from the Anambas. The relationship of *Tupaia castanea* to these may be understood from the following key:

- Upperparts light (approximately the ferruginous of Ridgway).
  - Head, neck, and shoulders paler than back; feet not darker than legs. *Tupaia lucida.*
  - Head, neck, and shoulders not paler than back; feet darker than legs. *Tupaia chrysomalla.*
- Upperparts dark (approximately the chestnut of Ridgway).
  - Underparts buff; total length about 320; hind foot about 41 (39). *Tupaia splendidula.*
  - Underparts tawny-ochraceous; total length about 350; hind foot about 45 (43).....*Tupaia castanea.*

The distribution of these treeshrews is difficult to understand. They are unknown on the mainland of the Malay Peninsula or on any of the larger islands; but Pulo Bintang is distant from the

<sup>1</sup> Measurements in parenthesis are those of an adult female *Tupaia splendidula* from Bunguran Island, North Natunas (No. 104,714).

coast of Johore by only 11 miles, while nearly 300 miles of open water lie between it and the Anambas, and a similar expanse separates the latter group from the Natunas. This apparent anomaly is doubtless in large part due to our very fragmentary knowledge of the fauna of the larger Malayan land masses.

**TUPAIA PULONIS** sp. nov.

*Type*.—Adult female (skin and skull), No. 112,449, United States National Museum. Collected on Pulo Aor, off coast of Johore, June 7, 1901, by Dr. W. L. Abbott. Original number, 1023.

*Characters*.—Similar to *Tupaia ferruginea* Raffles, but size larger, color of underparts much paler, and skull with rostral portion less elongate.

*Color*.—Back and sides ochraceous-rufous, inconspicuously speckled by the black hair tips. On sides the ground color becomes somewhat lighter, and on neck, shoulders, and outer surface of front legs it fades to ochraceous-buff, the speckling at the same time becoming more evident. Head and feet an indefinite grizzled brown, the exact shade not far from the hair-brown of Ridgway. Shoulder stripes distinct, cream-buff. Underparts and inner surface of legs cream-buff in strong contrast with color of sides. Tail somewhat lighter than back, its upper surface a grizzle of black and dull cream-buff, its under surface clear buff at middle, grizzled buff and black along edges and at tip.

*Skull and teeth*.—The skull is larger than that of *Tupaia ferruginea* throughout, and in form it is relatively broader and more robust, particularly in the rostral portion. Teeth larger than those of *Tupaia ferruginea*, but of similar form. The larger size of the teeth is especially noticeable in the anterior upper molar, the posterior lower premolar, and the first and second lower molars.

*Measurements*.—External measurements of type: total length, 372; head and body, 197; tail vertebræ, 175; hind foot, 42 (40). External measurements of immature<sup>1</sup> male from the type locality: total length, 385; head and body, 195; tail vertebræ, 190; hind foot, 44 (42).

Cranial measurements of type: greatest length, 51.4 (49);<sup>2</sup> basal length, 45.8 (43); basilar length, 44.6 (41.6); palatal length, 27 (25.4); diastema, 3 (3.6); breadth of palate at middle of diastema, 6.8 (5.4); breadth of palate between middle molars, 9.8 (8); least

<sup>1</sup> Permanent dentition not wholly in place.

<sup>2</sup> Measurements in parenthesis are those of an adult female *Tupaia ferruginea* from Tanjong Dungun, Tringanu (No. 105,029).

interorbital breadth, 15.6 (13.8); zygomatic breadth, 26.4 (24); breadth of braincase above roots of zygomata, 19.6 (19); maxillary toothrow exclusive of incisors (alveoli), 19 (18); mandible, 35.4 (33.6); mandibular toothrow exclusive of incisors (alveoli), 19.4 (18); crowns of first and second lower molars together, 7 (6.2).

*Specimens examined.*—Two, both from Pulo Aor.

*Remarks.*—Its large size and the pale color of the underparts readily distinguish this species from *Tupaia ferruginea*. The color of the back, however, is essentially as in the animal inhabiting the neighboring portions of the Malay Peninsula, though the upper surface of the tail is not as dark nor as strongly suffused with yellow.

#### TUPAIA TEPHRURA sp. nov.

*Type.*—Adult female (skin and skull), No. 121,752, United States National Museum. Collected on Tana Bala, Batu Islands, Sumatra, February 12, 1903, by Dr. W. L. Abbott. Original number, 2276.

*Characters.*—In size and general appearance not unlike *Tupaia phæura* of Sinkep Island, but upperparts darker, shoulder stripes better developed, and tail conspicuously lighter than body, its distal half silvery buff-gray.

*Color.*—Type: upperparts mixed ferruginous and black, the former in excess on neck, shoulders, and anterior half of back, the latter in excess posteriorly. On crown the ferruginous is replaced by buff. Shoulder stripes buff, well developed, about 4 mm. wide at middle. Feet and ears blackish. Underparts buff somewhat darker than that of Ridgway, particularly on middle of chest; the anterior half of belly darkened by the brownish under color. Tail light buff, the proximal half heavily overlaid with blackish brown above, the distal half grizzled with blackish and silvery, the under side clear buff throughout, except brownish line along vertebræ and brownish edging.

*Skull and teeth.*—The skull and teeth do not differ appreciably from those of *Tupaia phæura*.

*Measurements.*—External measurements of type: total length, 323; head and body, 193; tail vertebræ, 130; hind foot, 41 (38.6). External measurements of adult male (No. 121,751) from the type locality: total length, 330; head and body, 180; tail vertebræ, 150; hind foot, 45 (42.6).

Cranial measurements of type: greatest length, 52; basal length, 46.4; basilar length, 45; palatal length, 28; diastema, 4; breadth of palate between middle molars, 9.2; least interorbital breadth, 15; zygomatic breadth, 25; breadth of braincase above roots of zygomata,

20; maxillary toothrow exclusive of incisors (alveoli), 19; mandible, 35; mandibular toothrow exclusive of incisors (alveoli), 19.4.

*Specimens examined*.—Two, both from Tana Bala.

*Remarks*.—The color of the underparts is exactly as in *Tupaia phœura*, that of the upperparts is slightly darker, and the tail is very different from that of the related species. When the hairs are in natural position the basal half of the tail does not differ appreciably in color from the back, except that the silvery tips of the hairs are more noticeable. The least disarrangement, however, brings to view the buff under color. The distal half is very different from the back, and the whole under side is very much lighter than in *Tupaia phœura*. Both specimens are in fresh, unworn pelage. In the male the shoulders and back are not quite as dark as in the female, and the buff of the tail is much paler. Otherwise the two specimens are essentially alike.

**TUPAIA CHRYSOGASTER** sp. nov.

(PLATE X, FIGURE 1)

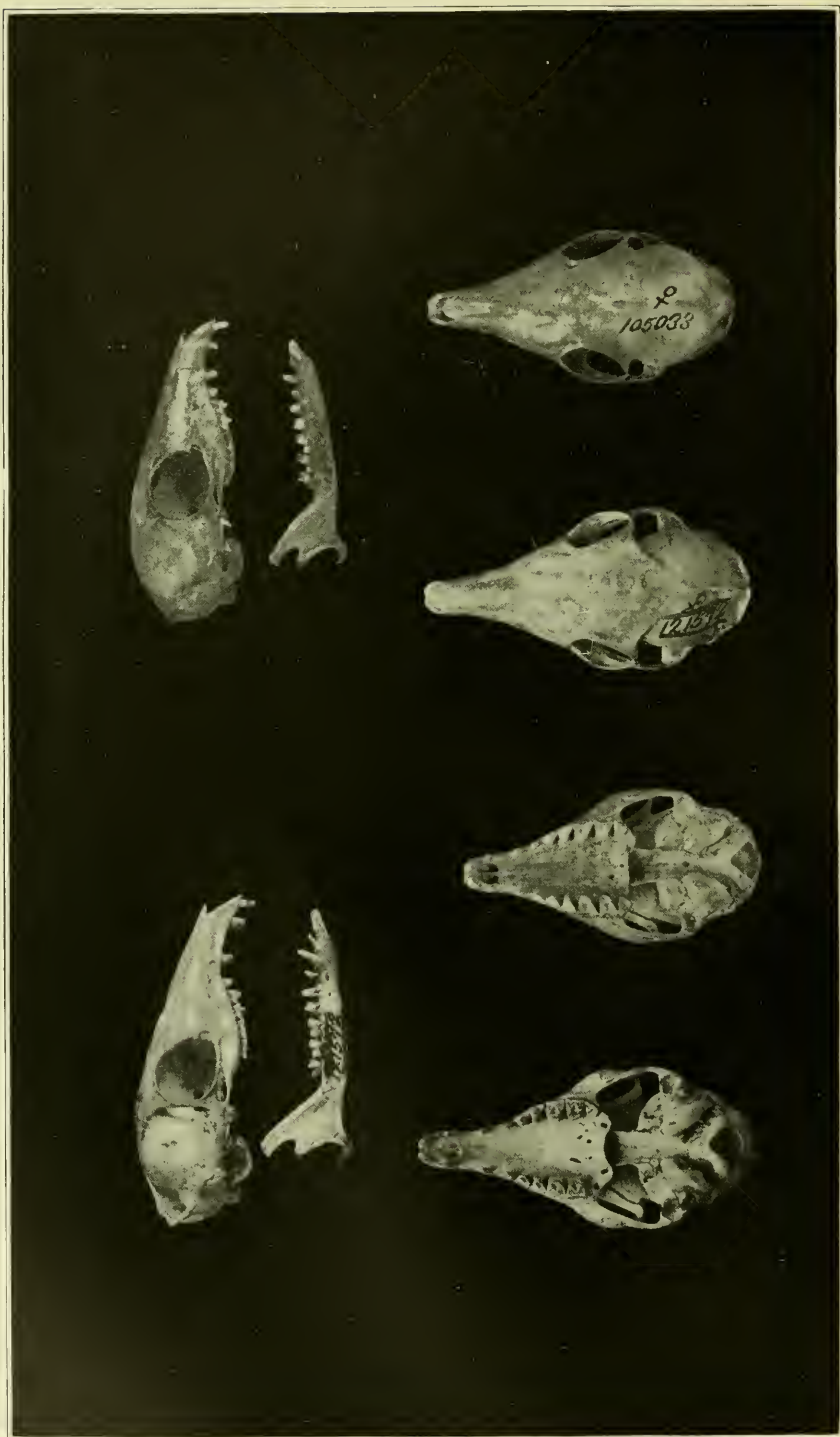
*Type*.—Adult female (skin and skull), No. 121,572, United States National Museum. Collected on North Pagi Island, Sumatra, November 21, 1902, by Dr. W. L. Abbott. Original number, 2078.

*Characters*.—Like the Javan *Tupaia hypochrysa* (Thomas), but upperparts darker than in *Tupaia ferruginea*, tail strongly tinged with yellowish brown below, and entire ventral surface of body and inner side of legs brownish yellow.

*Color*.—Type: upperparts and outer side of legs a fine, inconspicuous grizzle of black and dull ferruginous, the former in excess everywhere except on neck and along sides of body. Face slightly tinged with gray. Feet and ears blackish, but not strongly contrasted with surrounding parts. Ventral surface of body and inner side of legs clear brownish yellow, the exact shade ochraceous on throat, chest, legs, and along median line, somewhat tinged with clay-color elsewhere. The two colors form a rather sharp line of demarkation on legs, but on sides the fur is thin and the shades less definite. Wrists and ankles tinged with blackish. Tail like back above, but more coarsely grizzled, its under side a peculiar indefinite grizzled yellowish brown, very different from the gray of *Tupaia ferruginea*.

*Skull and teeth*.—The skull and teeth (pl. x, fig. 1) are larger than in *Tupaia ferruginea* (pl. x, fig. 2) and with age the rostrum becomes decidedly more elongate than is ever the case with the mainland animal. In the latter character the skull is intermediate between that of *Tupaia ferruginea* and that of *T. tana*. Its other





1<sup>a</sup> 1. *Tupaia chrysogaster*, female (type). 2. *Tupaia ferruginea*, No. 105933, Tanjong Dungun, Tringauu. 2<sup>b</sup>



details of form are, however, in essential agreement with the skull of *Tupaia ferruginea*.

*Measurements*.—External measurements of type: total length, 345; head and body, 205; tail vertebræ, 140; hind foot, 44.4 (42). External measurements of an adult male (No. 197,138) from the type locality: total length, 335; head and body, 197; tail vertebræ, 138; hind foot, 44 (42).

Cranial measurements of type: greatest length, 56 (49.4),<sup>1</sup> basal length, 49 (44); basilar length, 48 (42); palatal length, 30.6 (26.4); diastema, 5 (4.2); least distance from rim of orbit to tip of premaxillary, 26.6 (22.6); breadth of palate between middle molars, 9 (8.6); least interorbital breadth, 15 (14.8); zygomatic breadth, 26.6 (25); breadth of braincase above roots of zygomata, 20 (19); mandible, 38 (33); maxillary tooththrow exclusive of incisors, 20 (18); mandibular tooththrow exclusive of incisors, 20 (18.6).

*Specimens examined*.—Ten, all from the Pagi Islands.

*Remarks*.—This series shows no important variation in color. In a few specimens there is a faintly indicated shoulder stripe, but in the majority, as in the type, there is no trace of this. The underparts are occasionally less bright than in the type, and the indefinite brown wash on sides of belly varies slightly in amount. Occasionally there is a slight grayish tinge at axilla.

This species needs comparison with only one other, the *Tupaia hypochrysa* of Thomas. In the Javan animal, however, the yellow of the underparts is "a rich golden colour, almost 'orpiment orange' of Ridgway," and is confined to the throat and chest. The rest of the coloration is said to be similar to that of *Tupaia ferruginea*. This would make the upperparts lighter than in *T. chrysogaster*, and the under side of the tail gray instead of yellowish brown.

#### TUPAIA CERVICALIS sp. nov.

*Type*.—Adult male (skin and skull), No. 121,754, United States National Museum. Collected on Tana Bala, Batu Islands, Sumatra, February 14, 1903, by Dr. W. L. Abbott. Original number, 2294.

*Characters*.—Like *Tupaia tana*, but gray neck markings paler, more extensive, and more conspicuous; black of back more sharply defined from red of sides, and teeth larger.

*Color*.—Type: the general color of underparts, tail, and back is essentially as in *Tupaia tana*, and requires no detailed description.

<sup>1</sup> Measurements in parenthesis are those of an adult female *Tupaia ferruginea* from Singapore (No. 105,079).

The sides, however, are a lighter, duller ochraceous-rufous, and the posterior half of back a deeper, more glossy black. The black area is thus better outlined laterally, while the very sharp contrast with the shoulders and neck throw it still more strongly in relief. Light neck stripes grizzled, whitish cream-buff, slightly tinged with tawny on posterior third, very sharply defined against the tawny sides of neck and blackish median stripe. Crown and face a dull grizzle of whitish and dark brown, nearly as pale as light neck stripes.

*Skull and teeth.*—The skull is in all respects similar to that of *Tupaia tana*. Teeth as in the related species, but molars larger.

*Measurements.*—External measurements of type: total length, 375; head and body, 210; tail vertebræ, 165; hind foot, 46 (44). External measurements of adult female from the type locality: total length, 365; head and body, 215; tail vertebræ, 150; hind foot, 45.4 (42).

Cranial measurements of type: greatest length, 59; basal length, 52; basilar length, 51; palatal length, 33; diastema, 5; breadth of palate between middle molars, 8.6; least interorbital breadth, 14.8; zygomatic breadth, 25; breadth of braincase above roots of zygomata, 20; maxillary tooththrow exclusive of incisors (alveoli), 22; mandible, 39; mandibular tooththrow exclusive of incisors (alveoli), 22.

*Specimens examined.*—Two, both from Tana Bala.

#### PTEROPUS GEMINORUM sp. nov.

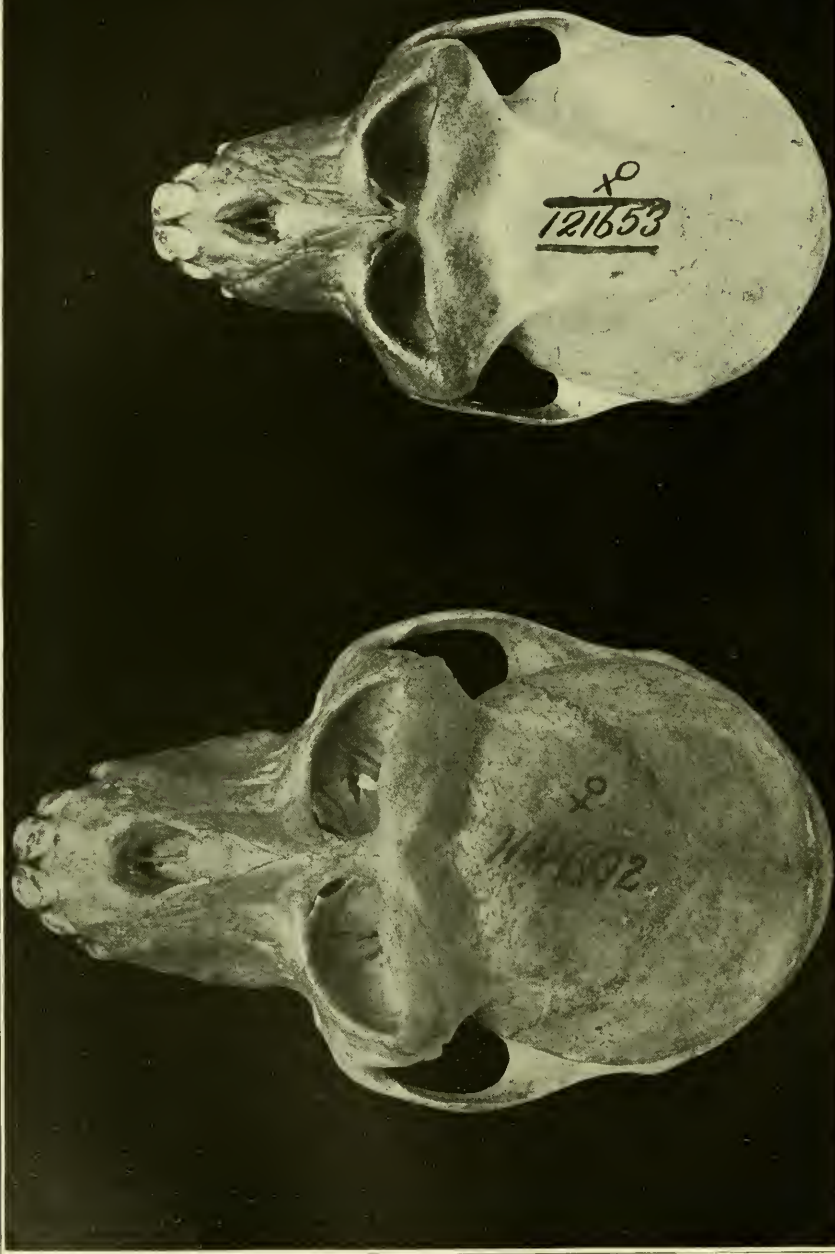
*Type.*—Adult female (skin and skull), No. 104,464, United States National Museum. Collected on South Twin Island, Mergui Archipelago, January 28, 1900, by Dr. W. L. Abbott. Original number, 283.

*Characters.*—Similar to *Pteropus hypomelanus* and *P. lepidus*, but color darker and teeth smaller.

*Color.*—Type: back dark hair-brown, sprinkled with silvery whitish hairs, and with an indistinct brownish yellow wash along edges of membrane. Neck russet, blackening laterally. Head grayish ochraceous-buff. Underparts blackish, irregularly suffused with russet and sprinkled with silvery whitish hair-tips. Ears, feet, and membranes black.

*Skull and teeth.*—The skull is in all respects essentially like that of *Pteropus hypomelanus* from the Natuna Islands, though the palate is usually less broad. Teeth as in *Pteropus hypomelanus* but smaller, the difference particularly noticeable in the second upper molar and first lower molar.





1. *Macacus nemestrinus*, female, No. 114,502, Tapanuli Bay, Sumatra. 2. *Macacus pagensis*, female (type).

*Measurements.*—External measurements of type: head and body, 215; tibia, 55; foot, 45 (36); forearm, 115; thumb, 62 (52); second digit, 105 (103); third digit, 257; fourth digit, 202; fifth digit, 177; ear from meatus, 23; ear from crown, 21; width of ear, 15.

Cranial measurements of type: greatest length, 64; basal length, 60; basilar length, 56; median palatal length, 35; palatal breadth between anterior molars, 10; zygomatic breadth, 33; least inter-orbital breadth in front of postorbital processes, 8.4; least inter-orbital breadth behind postorbital processes, 8; distance between tips of postorbital processes, 24; greatest breadth of braincase above roots of zygomata, 23; greatest depth of braincase, 18; occipital depth, 12; depth of rostrum at middle of diastema, 6.8; maxillary toothrow (exclusive of incisors), 23.4; crown of first upper molar,  $4.8 \times 3$ ; mandible, 49.4; mandibular toothrow (exclusive of incisors), 27; crown of first lower molar,  $4.4 \times 2.6$ .

*Specimens examined.*—Fifteen (seven skins), all from South Twin Island.

*Remarks.*—The series shows little variation in color. Such as there is chiefly involves the greater or less amount of blackish suffusion on the neck, and the strength of the yellowish tinge in the gray of the head. In one female (No. 104,466) the sides of the abdomen are strongly washed with silvery gray.

#### MACACUS PAGENSIS sp. nov.

(PLATE XI, FIGURE 2; PLATE XII, FIGURE 2; PLATE XIII, FIGURE 1)

*Type.*—Adult female (skin and skull), No. 121,653, United States National Museum. Collected on South Pagi Island, Sumatra, November 17, 1902, by Dr. W. L. Abbott. Original number, 2053.

*Characters.*—Like *Macacus nemestrinus* but much smaller. General color darker than in the related species, but sides of neck light yellowish brown, in strong contrast with dorsal surface.

*Fur.*—The fur does not differ essentially from that of an adult female Sumatran specimen, except that the tail is much more thinly haired, and there are some peculiarities in the growth of the hair on head. The tail is so sparsely haired that the skin is nowhere concealed except at extreme base, while in *M. nemestrinus* no skin can be seen. This may be a seasonal character, but the fact that the scattered hairs on the tail of *Macacus pagensis* are all of the same light brown color, those of the upper surface showing no suggestion of the blackish dorsal stripe of the related animal, makes it seem probable that the tail is always essentially as in the type. On forehead the hairs from a line joining anterior bases of ears all grow

forward, while in *M. nemestrinus* those in a band about 20 mm. wide above the eyebrows grow backward, meeting the others in an indistinct ridge. The hairs of the cheeks are all directed backward, to and surrounding base of ears. There is thus no indication of the conspicuous semicircle of antrorse hairs surrounding front of ear in the larger species.

*Color.*—Dorsal surface from forehead to base of tail clear bister, darker than that of Ridgway, the drab underfur appearing irregularly at surface when hair is disarranged. Sides of body and inner surface of arms and legs isabella-color. Belly isabella-color, fading to light fawn-color on chest and throat. Outer surface of arms light russet, that of legs dark isabella-color except on thighs, which are mostly covered by an extension of the brown area of back. A similar but less extensive wash covers proximal half of upper arm. Sides of neck grayish cream-buff in striking contrast with upper surface. Cheeks and chin brown like that of back, but not quite as dark. Hands and feet dusky brownish. Tail sprinkled with isabella-colored hairs. "Callosities fleshy brown. Palms and soles light fleshy brown."<sup>1</sup>

*Skull and teeth.*—The skull (pl. XI, fig. 2; pl. XII, fig. 2; pl. XIII, fig. 1) is very much smaller than that of a slightly younger female of *Macacus nemestrinus* (pl. XI, fig. 1; pl. XII, fig. 1; pl. XIII, fig. 2) from Tapanuli Bay, Sumatra. In general form, however, the two do not appreciably differ. The bony palate is concave laterally (when viewed from below, but to a less degree than in the larger animal. Its median line is nearly straight, and shows only a trace of the deep longitudinal concavity so conspicuous in *M. nemestrinus* in region between premolars. Audital bullæ a little more swollen antero-laterally than in *M. nemestrinus*, but this character may be purely individual. Teeth as in *Macacus nemestrinus* but smaller throughout. In the larger animal the last upper molar is provided with a distinct fifth cusp on the outer posterior margin of the crown. Scarcely a trace of this can be detected in *Macacus pagensis*. Similarly the back lower molar has one less cusp than that of *Macacus nemestrinus*. The missing cusp in this tooth appears to be the posterior on inner side. Whether these differences are any more than individual peculiarities it is impossible to tell.

*Measurements.*—External measurements of type: total length, 580 (690);<sup>2</sup> head and body, 435 (480); tail vertebræ, 145 (210);

<sup>1</sup> Collector's note on label.

<sup>2</sup> Measurements in parenthesis are those of a younger female of *Macacus nemestrinus* from Tapanuli Bay, Sumatra (No. 114,502).





1. *Macacus nemestrinus*, female, No. 114,502, Tapanuli Bay, Sumatra.



2. *Macacus pugensis*, female (type).



foot, 125 (152); foot without claws, 120 (148); ear from meatus, 31 (32); ear from crown, 28 (26); width of ear, 30 (32).

Cranial measurements of type: greatest length, 111 (134); basal length, 78 (96); basilar length, 76 (92); least palatal length, 38 (52.4); palatal breadth between front molars, 20.6 (26.4); zygomatic breadth, 71 (85); mastoid breadth, 62.6 (72); greatest breadth of braincase above roots of zygomata, 61 (68); least breadth of braincase immediately behind orbits, 42 (50); greatest orbital breadth, 60 (66); least distance from orbit to alveolus of inner incisor, 33 (47.6) greatest depth of braincase, 47.4 (48); mandible, 79.6 (94); maxillary toothrow exclusive of incisors (alveoli), 35.4 (41.6); three upper molars together (crowns), 22.6 (26); mandibular toothrow exclusive of incisors (alveoli), 40.4 (47); three lower molars together (crowns), 23.4 (28).

*Specimens examined*.—Two, the type, and a very young individual, both from South Pagi Island.

*Remarks*.—The young, of which the type was the parent, closely resembles the adult in all respects, except that the tail is somewhat less thinly haired.

#### MACACUS PHÆURA sp. nov.

*Type*.—Adult male (skin and skull), No. 121,870, United States National Museum. Collected at Siaba Bay, Nias Island, Sumatra, March 20, 1903, by Dr. W. L. Abbott. Original number, 2399.

*Characters*.—Similar to *Macacus fascicularis*,<sup>1</sup> but general color slightly darker, and upper surface of tail conspicuously blackish.

*Color*.—Type: back and sides buff, slightly browner and more yellow than that of Ridgway, and everywhere inconspicuously grizzled with black. The sides are a trifle less yellowish than the back. Outer surface of arms like sides of body, but distinctly tinged with gray; outer surface of legs essentially like sides of body. Fingers, toes, and sides of feet indefinite dark brown. Crown like back. Forehead sprinkled with blackish hairs. Cheeks grizzled buffy gray. Underparts, sides of neck, and inner surface of legs pale ecru-drab. Tail ecru-drab below, blackish above. Near base the hairs of the upper surface of the tail are inconspicuously grizzled with buffy brown annulations. Beyond middle the blackish becomes diluted with ecru-drab.

*Skull and teeth*.—The skull and teeth show no tangible characters to distinguish them from those of *Macacus fascicularis*.

<sup>1</sup>For use of the name *Macacus fascicularis* (Raffles) in place of *M. cynomolgus* see Bonhote, *Fasciculi Malayenses*, Zoology, I, p. 3. July, 1903.

*Measurements.*—External measurements of type: total length, 940; head and body, 460; tail vertebræ, 480; foot, 130 (127); skull, greatest length, 116; basal length, 85; basilar length, 82; zygomatic breadth, 77; maxillary toothrow exclusive of incisors (alveoli), 34.

*Specimens examined.*—Four, all from Siaba Bay, Nias Island.

*Remarks.*—Although the characters on which this species is based are slight they are very constant in the four skins as compared with an extensive series of *Macacus fascicularis* from various localities in Sumatra, the Malay Peninsula, and elsewhere.

#### PRESBYTES RHIONIS sp. nov.

*Type.*—Adult female (skin and skull), No. 115,665, United States National Museum. Collected at Telok Pemudong, Pulo Bintang, Rhio Archipelago, August 15, 1902, by Dr. W. L. Abbott. Original number, 1888.

*Characters.*—Like *Presbytes natunæ* (Thomas and Hartert), but color not as dark.

*Color.*—Type: general color above, from region between ears to and including basal fourth of tail, broccoli-brown, washed with wood-brown on shoulders and tail and with chocolate on sides and lumbar region. The hairs are ecru-drab at base, and the irregular appearance of this color at surface further complicates any attempt at an exact description. From axilla to thigh may be traced a faintly indicated dark line about 25 mm. in width bordering the whitish of ventral surface. Front part of crown darker than back, the color becoming almost black on forehead and temples. Feet and hands blackish. On arms this color fades into the general tint of the body at region of elbows, but on legs it is continued, with only a slight admixture of brown, to thigh patch, and along outer side of this to join the faint dark lateral stripe. Thigh patches large and conspicuous, as in *Presbytes natunæ*, white, slightly tinged with cream-color. Above they are sharply defined from the brown lumbar region, but below and at the sides they fade somewhat gradually into the color of the neighboring parts. Entire ventral surface, inner side of arms to elbows and of legs to knee white, tinged with gray, particularly on chest and thighs. The light area on arms and legs is continued to wrists and ankles, but beyond knees and elbows it is much encroached upon by the dark brown. The tail darkens from proximal fourth until at tip it is seal-brown. The under surface is nowhere different from the upper surface.

The series shows some trifling variations in the exact shade of the dark areas, but this is chiefly due to bleaching of the hairs, and none



1. *Macacus pagensis*, female (type). 2. *Macacus nemestrinus*, female,  
No. 114,502, Tapanuli Bay, Sumatra.



of the skins shows any very close approach to the blackish hues of *Presbytes natunæ*.

*Skull and teeth.*—The skull and teeth appear to be identical with those of *Presbytes natunæ*.

*Measurements.*—External measurements of type: total length, 1173; head and body, 468; tail vertebrae, 705; foot, 150 (145). Measurements of adult male from type locality: total length, 1213; head and body, 550; tail vertebrae, 663; foot, 150 (147).

Cranial measurements of type: greatest length, 88 (86);<sup>1</sup> basal length, 63 (61); basilar length, 57 (56); least palatal length, 24 (23); palatal breadth (between front molars), 18.8 (18); zygomatic breadth, 66 (65); mastoid breadth, 58.4 (54); greatest breadth of braincase above roots of zygomata, 52.4 (52); least breadth of braincase immediately behind orbits, 46 (43); greatest orbital breadth, 62 (57.6); least distance from orbit to alveolus of inner incisor, 15.6 (15.6); greatest depth of braincase, 43 (43); mandible, 61 (62); maxillary toothrow (exclusive of incisors), 27 (26); mandibular toothrow (exclusive of incisors), 32.2 (31.8).

*Specimens examined.*—Seven (one skull without skin), all from Pulo Bintang.

*Remarks.*—Although closely related to *Presbytes natunæ*, this monkey is readily distinguishable by the absence of the blackish cast on back, legs, and tail. It is common on Pulo Bintang, and Dr. Abbott notes that its cry is exactly like the shrill *ka—ka—ka* of *P. natunæ* and *P. sumatranus*. From this cry is derived the Malay name, "kaka." In the living and freshly killed animals the palms and soles are black, the face is slaty, and the eyelids and lips are fleshy white.

#### PRESBYTES BATUANUS sp. nov.

*Type.*—Adult male (skin and skull), No. 121,810, United States National Museum. Collected on Pulo Pinie, Batu Islands, Sumatra, March 4, 1903, by Dr. W. L. Abbott. Original number, 2369.

*Characters.*—Similar to *Presbytes sumatranus*, but not as large and tail not as long. Skull somewhat broader than in the Sumatran animal.

*Color.*—Type: belly, under side of tail to about middle, inner surface of thighs, and median line of chest grayish white. Remainder of fur black, the back and crown lightened by a brownish wash. Beyond middle of tail the grayish white stripe on ventral surface becomes much reduced in width, and its distinctness is further

<sup>1</sup> Measurements in parenthesis are those of an adult female *Presbytes natunæ* from Bunguran Island (No. 104,849).



of the skins shows any very close approach to the blackish hues of *Presbytes natunæ*.

*Skull and teeth*.—The skull and teeth appear to be identical with those of *Presbytes natunæ*.

*Measurements*.—External measurements of type: total length, 1173; head and body, 468; tail vertebræ, 705; foot, 150 (145). Measurements of adult male from type locality: total length, 1213; head and body, 550; tail vertebræ, 663; foot, 150 (147).

Cranial measurements of type: greatest length, 88 (86);<sup>1</sup> basal length, 63 (61); basilar length, 57 (56); least palatal length, 24 (23); palatal breadth (between front molars), 18.8 (18); zygomatic breadth, 66 (65); mastoid breadth, 58.4 (54); greatest breadth of braincase above roots of zygomata, 52.4 (52); least breadth of braincase immediately behind orbits, 46 (43); greatest orbital breadth, 62 (57.6); least distance from orbit to alveolus of inner incisor, 15.6 (15.6); greatest depth of braincase, 43 (43); mandible, 61 (62); maxillary toothrow (exclusive of incisors), 27 (26); mandibular toothrow (exclusive of incisors), 32.2 (31.8).

*Specimens examined*.—Seven (one skull without skin), all from Pulo Bintang.

*Remarks*.—Although closely related to *Presbytes natunæ*, this monkey is readily distinguishable by the absence of the blackish cast on back, legs, and tail. It is common on Pulo Bintang, and Dr. Abbott notes that its cry is exactly like the shrill *ka—ka—ka* of *P. natunæ* and *P. sumatranus*. From this cry is derived the Malay name, "kaka." In the living and freshly killed animals the palms and soles are black, the face is slaty, and the eyelids and lips are fleshy white.

#### PRESBYTES BATUANUS sp. nov.

*Type*.—Adult male (skin and skull), No. 121,810, United States National Museum. Collected on Pulo Pinie, Batu Islands, Sumatra, March 4, 1903, by Dr. W. L. Abbott. Original number, 2369.

*Characters*.—Similar to *Presbytes sumatranus*, but not as large and tail not as long. Skull somewhat broader than in the Sumatran animal.

*Color*.—Type: belly, under side of tail to about middle, inner surface of thighs, and median line of chest grayish white. Remainder of fur black, the back and crown lightened by a brownish wash. Beyond middle of tail the grayish white stripe on ventral surface becomes much reduced in width, and its distinctness is further

<sup>1</sup> Measurements in parenthesis are those of an adult female *Presbytes natunæ* from Bunguran Island (No. 104,849).

lessened by admixture of black hairs. It may be traced however to extreme tip, which is also grayish. The gray of the tail is somewhat washed with pale buff.

*Skull and teeth.*—The skull of *Presbytes batuanus* is smaller than that of *P. sumatranus* and its width is greater in proportion to the length. The orbits are better defined from outline of braincase above, and the frontal region is less swollen. Teeth as in *Presbytes sumatranus*, but uniformly smaller.

*Measurements.*—External measurements of type: total length, 1150; head and body, 485; tail vertebrae, 665; foot, 163 (161).

Cranial measurements of type: greatest length, 90 (96.4)<sup>1</sup>; basal length, 64.6 (69); basilar length, 59 (65); median palatal length, 29 (30); palatal breadth between front molars, 17.4 (18); zygomatic breadth, 72 (73); mastoid breadth, 58 (62); greatest breadth of braincase above roots of zygomata, 52.6 (56); least breadth of braincase immediately behind orbits, 41 (43); greatest orbital breadth, 61.4 (62); least distance from orbit to alveolus of inner incisor, 17 (21); greatest depth of braincase, 42.6 (44.6); mandible, 64 (66.6); maxillary toothrow exclusive of incisors (alveoli), 28 (29); three upper molars together (crowns), 16.8 (16.8); mandibular toothrow exclusive of incisors (alveoli), 33 (32); three lower molars together (crowns), 18.4 (17).

*Specimens examined.*—Ten, all from the Batu Islands.

*Remarks.*—The Batu *Presbytes* is readily distinguishable from its Sumatran representative by the smaller general size, and particularly by the shorter tail. Of four adults of the latter from Tapanuli Bay none has the tail less than 730 mm. in length, while among the nine adults of *Presbytes batuanus* the longest tail is only 710 mm. The series shows no variations worthy of special note.

#### SIMIAS gen. nov. (Cercopithecidae).

*Type.*—*Simias concolor* sp. nov.

*Characters.*—Skull essentially as in *Nasalis*, but rostrum less produced and nasals not as wide. Nose like that of *Rhinopithecus*. Tail about one-third as long as head and body, naked except for an inconspicuous tuft of hair at tip. Ischial callosities large and conspicuous. Teeth as in *Nasalis*, *Rhinopithecus*, and *Presbytes*. No cheek pouches.

*Remarks.*—This genus combines the more important structural characters of *Nasalis* and *Rhinopithecus* with an external form un-

<sup>1</sup>Measurements in parenthesis are those of an adult male *Presbytes sumatranus* from Tapanuli Bay, Sumatra (No. 114,507).





*Simias concolor* (from photograph of freshly killed individual).



like that of its relatives and strongly suggesting *Macacus nemestrinus*. The nasal bones are fully as long as in *Nasalis larvatus*, though their width is less and their anterior extremities probably never form a distinct median projection. Among the nine skulls that I have examined none shows any tendency toward the rudimentary form of nasals characteristic of *Presbytes* and to an even greater degree of *Rhinopithecus*. The interorbital region is relatively longer and narrower than in any of the related genera, and the orbits are better defined above, two characters that give the skull a strong resemblance to that of *Macacus*. The facial profile is nearly straight from forehead to middle of nares. The development of the rostrum is intermediate between that of *Nasalis* and *Presbytes*, and appears to be closely similar to that in the two species of *Rhinopithecus* whose skulls are known. The teeth do not differ appreciably from those of the members of the related genera. Although the skull agrees so closely with that of *Nasalis* the nose is very different, showing no tubular elongation. As in *Rhinopithecus* the apertures of the nostrils are directly on the surface of the very wide upper lip; and it is only the superior nasal margin that is lengthened to give the face its snub-nosed aspect. While the structural characters of the head are essentially a combination of those of the previously known genera, the form of the body departs widely from that of other members of the subfamily *Presbytinae*, particularly in the shortness of the arms and tail, and resembles the pig-tailed macaques. The limbs are not as robust as in *Macacus nemestrinus*, but the tail is of about the same relative length, and the ischial callosities are fully as conspicuous. Although distinct from each other and from *Presbytes*, the genera *Nasalis*, *Rhinopithecus*, and *Simias* form a compact and easily recognizable group.

**SIMIAS CONCOLOR** sp. nov.

(PLATES XIV, XV, XVI)

*Type*.—Adult male (skin and skull), No. 121,659, United States National Museum. Collected on South Pagi Island, Sumatra, December 3, 1902, by Dr. W. L. Abbott. Original number, 2103.

*Characters*.—Nose and teeth essentially like those of *Rhinopithecus roxellana* and *R. bieti* as described and figured by Milne-Edwards. Skull essentially as in *Nasalis larvatus* but smaller, the rostrum less produced, and nasal bones narrower. Size and general form about as in *Macacus nemestrinus*; tail only one-third as long as head and body, naked except for an inconspicuous tuft of hair at tip. General color throughout dusky brown, the underparts darker than back.

*External form.*—In general external form this species very closely resembles *Macacus nemestrinus*, differing only in its slightly longer, less robust arms and legs, and relatively smaller, more rounded head. The hands and feet appear to be broader. The tail is proportioned almost exactly as in *Macacus nemestrinus*.

*Face.*—The physiognomy of *Simias concolor*, as shown by photographs of a freshly killed individual (pl. XIV) is essentially like that of *Rhinopithecus roxellana*. The elevated ridge above the nostrils is less abrupt than in the Tibetan animal as figured by Milne-Edwards, and the concavity extending from this ridge to the eyebrows is longer and less deep. Otherwise there is a very close agreement between the two species.

*Callosities.*—The callosities are very large and conspicuous, even more so than in *Macacus nemestrinus*. In the male they are joined solidly together along the median line, but in the female they are separated by a narrow strip of softer skin.

*Fur.*—The fur is of the same length as that of *Macacus nemestrinus*, except that the underparts are thickly haired from chin to hypogastric region. The latter, together with the axillæ and inner side of upper arm are nearly bare. On head the hair spreads uniformly from forehead, that of middle growing directly backwards, that of sides standing out as distinct tufts over ears. On cheeks the hairs grow upwards, meeting the ear tufts and continuing them backward beneath ears. Slightly below middle of cheek the hair abruptly changes direction and grows downward, forming a thin tuft on each side of the chin. Like rest of under surface of body the chin is closely furred except the space immediately about lips. On shoulders and back of neck the hairs are slightly elongated, but not enough to form a distinct cape.

*Color.*—Type: general color throughout clove-brown somewhat lightened by drabby reflections. On underparts, head, legs, lumbar region, and terminal tuft of tail, the brown is unmixed with lighter color, and on hands and feet it darkens almost to black. On neck, shoulders, outer side of upperarm, and entire back to lumbar region, most of the hairs have a buff annulation about 4 mm. in width near tip. These annulations are most abundant on neck and shoulders, where they are also paler than elsewhere, approaching a grayish cream-buff. In this region they produce a distinct grizzled effect, much like that of the same parts in *Macacus umbrosus* and *M. fuscus*. On sides of body they become less distinct than on back, and the ground color at the same time changes to a rather dark broccoli-brown. The naked portion of face and chin is bordered by





*Simias concolor*, male (type).





*Simias concolor*, male (type).



whitish hairs, but these are not numerous enough to be very conspicuous. "Palms, soles, face, and callosities black in both sexes. Anus pinkish white in male. Iris brown."<sup>1</sup>

*Skull and teeth.*—The skull (pls. xv, xvi) rather closely resembles that of an adult male *Nasalis larvatus*, but is considerably smaller; the rostral portion is less developed, and the upper margins of the orbits are more distinctly outlined from the braincase. As compared with the skulls of *Rhinopithecus* figured by Milne-Edwards, the width is less in proportion to the length, the anterior nares are narrower, the orbits are nearer together, the ridge above them is less curved, and the whole facial aspect is more suggestive of *Macacus*. Rostrum decidedly more produced than in the Tibetan species. Teeth essentially as in *Presbytes*, but inner cusps of upper molars and outer cusps of lower molars even better developed and in height almost equal to those of the opposite side of the teeth.

*Measurements.*—External measurements of type: total length, 740; head and body, 550; tail vertebræ, 190; pencil, 20; foot, 170; ear from meatus, 24; ear from crown, 12; width of ear, 24. External measurements of an adult female (No. 121,658) from South Pagi Island: total length, 650; head and body, 550; tail vertebræ, 100; pencil, 10; foot, 150.

Cranial measurements of type: greatest length, 106; basal length, 82; basilar length, 77; median palatal length, 36; palatal breadth between front molars, 21.6; zygomatic breadth, 75.4; mastoid breadth, 62; greatest breadth of braincase above roots of zygomata, 56; least breadth of braincase immediately behind orbits, 39.6; greatest orbital breadth, 64.6; least interorbital breadth, 8.8; least distance from orbit to alveolus of inner incisor, 32; greatest depth of braincase, 43; mandible, 74; depth of mandible at posterior end of last molar, 27.4; maxillary toothrow exclusive of incisors (alveoli), 34.6; three upper molars together (crowns), 21.6; mandibular toothrow exclusive of incisors (alveoli), 40.6; three lower molars together (crowns), 23.

*Specimens examined.*—Ten, all from South Pagi Island.

*Remarks.*—This monkey is so different from all other known species that further comparison is unnecessary.

The specimens show no appreciable variation, except that the females are uniformly much smaller than the males. Two young individuals (male, No. 121,655, and female, No. 121,656), 455 mm. and 465 mm. respectively in length, and with the milk dentition still in place, are light cream-buff throughout. Another (female, No.

<sup>1</sup>Collector's note; does not refer specifically to the type specimen.

121,662) of the same size is normal. In the type the tuft of hairs at end of tail is better developed than in any of the others. This tuft is occasionally represented by a mere lengthening of the short hairs that are sprinkled over the rest of the tail.

**SYMPHALANGUS KLOSSII** sp. nov.

(PLATE XVII, FIGURE 2; PLATE XVIII, FIGURE 2; PLATE XIX, FIGURE 1)

*Type*.—Adult male (skin and skull), No. 121,678, United States National Museum. Collected on South Pagi Island, Sumatra, November 13, 1902, by Dr. W. L. Abbott. Original number, 2032.

*Characters*.—A dwarf siamang of about half the weight of *Symphalangus syndactylus*. Fur shorter and less woolly than in the Sumatran animal. Throat densely furred in both sexes.

*Fur*.—The fur is moderately long, and of a silky texture, not coarse and woolly as in *Symphalangus syndactylus*. It shows only a slight tendency to lengthen on neck and shoulders, and scarcely any on thighs and outer surface of upper arms. On underparts it is rather shorter than elsewhere, becoming rather thin in hypogastric region, but on throat it continues uninterruptedly to chin. Eyebrows scarcely lengthened, giving the forehead a peculiar rounded appearance.

*Color*.—The color is black throughout, and there are no whitish hairs on face and chin.

*Skull and teeth*.—The skull and teeth (pl. xvii, fig. 2; pl. xviii, fig. 2; pl. xix, fig. 1) so closely resemble those of *Symphalangus syndactylus* (pl. xvii, fig. 1; pl. xviii, fig. 1; pl. xix, fig. 2) that I can detect no constant differences other than size.

*Measurements*.—External measurements of type: head and body, to symphysis pubis, 440 (525);<sup>1</sup> foot, 130 (154). External measurements of an adult female (No. 121,687) from the type locality: head and body, 445; foot, 123.

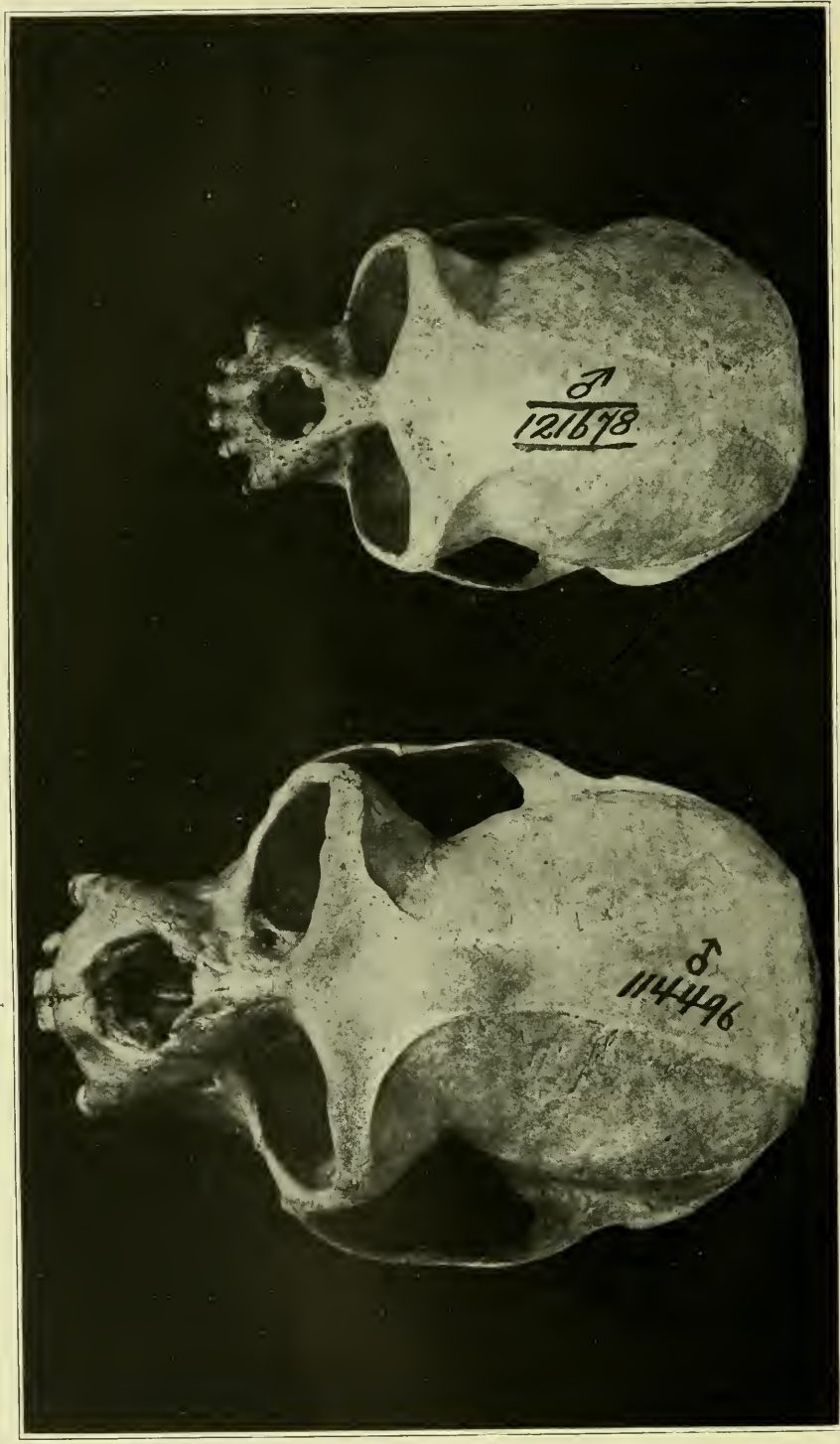
Cranial measurements of type: greatest length, 97 (129);<sup>1</sup> basal length, 75 (109); basilar length, 70 (104); median palatal length, 36.8 (59); palatal breadth between front molars, 16.4 (27); zygomatic breadth, 65 (90); mastoid breadth, 64 (78); greatest breadth of braincase above roots of zygomata, 56.6 (66); least breadth of braincase immediately behind orbits, 45.4 (49); greatest orbital breadth, 58 (75); least interorbital breadth, 9 (15); least distance from orbit to alveolus of middle incisor, 23.6 (38); greatest depth of braincase, 46 (55); mandible, 68 (95); depth of mandible at pos-

<sup>1</sup> Measurements in parenthesis are those of an adult male *Symphalangus syndactylus* from Tapanuli Bay, Sumatra (No. 114,496).



2

1



1. *Symphalangis syndactylus*, male, No. 114,496, Tapanuli Bay, Sumatra. 2. *Symphalangis klossii*, male (type).





1. *Symphalangus syndactylus*, male, No. 114,496, Tapanuli Bay, Sumatra. 2. *Symphalangus klossii*, male (type).

terior end of last molar, 10 (15.4); depth of mandible through coronoid process, 20.4 (36); maxillary toothrow exclusive of incisors (alveoli), 30.6 (45.4); three upper molars together (crowns), 14.8 (25); crown of first upper molar,  $5 \times 6$  ( $8 \times 7.6$ ); mandibular molar series exclusive of incisors (alveoli), 34 (50); three lower molars together (crowns), 17 (25.4); crown of first lower molar,  $5.8 \times 5$  ( $8.6 \times 7$ ).

*Weight.*—Weight of type, 6.12; weight of a second adult male, 5.21; weight of four adult females respectively, 5.21, 5.78, 6.12, and 6.46 kg.<sup>1</sup>

*Specimens examined.*—Eighteen (four young in alcohol), all from South Pagi Island.

*Remarks.*—At Dr. Abbott's request I have named this siamang after Mr. C. B. Kloss, to whose aid was due much of the success of the second expedition to the coast and islands of western Sumatra. The characters of the species are so striking that no special comparison is required with *Symphalangus syndactylus*, the only other member of the genus at present known.

#### LIST OF THE SPECIES DESCRIBED IN THIS PAPER.

<i>Tragulus batuanus</i> , p. 2.	<i>Sciurus matthæus</i> , p. 19.
<i>Tragulus russulus</i> , p. 3.	<i>Sciurus lucas</i> , p. 20.
<i>Ratufa insignis</i> , p. 4.	<i>Sciurus casensis</i> , p. 20.
<i>Ratufa conspicua</i> , p. 5.	<i>Sciurus altinsularis</i> , p. 21.
<i>Ratufa balæ</i> , p. 6.	<i>Sciurus rubeculus</i> , p. 22.
<i>Ratufa masæ</i> , p. 7.	<i>Funambulus obscurus</i> , p. 23.
<i>Ratufa piniensis</i> , p. 8.	<i>Funambulus rostratus</i> , p. 24.
<i>Sciurus bilimitatus</i> , p. 8.	<i>Funambulus peninsulae</i> , p. 25.
<i>Sciurus pemangilensis</i> , p. 9.	<i>Sciuropterus mærens</i> , p. 26.
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<i>Sciurus peninsularis</i> , p. 10.	<i>Mus stridens</i> , p. 28.
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- |   |                                       |
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# RECENT STUDIES OF THE SOLAR CONSTANT OF RADIATION

By C. G. ABBOT

## INTRODUCTION

Within the last two years the observations of the Smithsonian Astrophysical Observatory under the direction of the Secretary, Mr. Langley, have been largely for the purpose of measuring the total solar radiation, its distribution in the spectrum, and the losses which it suffers by absorption in the solar and terrestrial gaseous envelopes. In the experimental work and reduction of observations Mr. Langley has been aided by the writer, but chiefly by Mr. F. E. Fowle, Jr., whose able handling of the work I wish particularly to acknowledge and commend. Preliminary notices of this investigation have appeared in the *Smithsonian Report* for 1902, and in an article by the Secretary in *The Astrophysical Journal* for March, 1903, to which sources the reader is referred for additional information in relation to the methods of study. In the present paper will be found a summary of the results thus far reached.

## ATMOSPHERIC ABSORPTION

It is well known that the effectiveness of the solar and terrestrial gaseous envelopes to intercept by reflection or absorption and thus diminish the intensity of the solar radiations at the earth's surface, varies greatly for rays of different wave-length. It is customary, speaking of the matter in ready though not strictly accurate terms, to combine these two effects of reflection and absorption under the single head of absorption, but to distinguish two kinds of absorption, namely, general and selective, of which the latter includes such sudden alterations of transmission as are seen in the Fraunhofer lines, while the former denotes merely a general weakening of the radiation extending over wide ranges of wave-length. Using this nomenclature, it appears to be the general absorption of the solar and terrestrial envelopes which chiefly affects the amount of solar radiation at the earth's surface, although the selective absorption of

water vapor in the atmosphere is also both very effective and very variable.<sup>1</sup>

The procedure employed here to determine the general absorption of the air consists chiefly in making bolographs—that is, automatic energy spectra—of the solar radiation as often as possible throughout days of uniform and excellent sky without alteration of the sensitiveness of the apparatus. Such energy spectra are altered in appearance from one to another by the varying absorption of the different thicknesses of air, so that at a little after noon the height of the curve

---

<sup>1</sup>K. Ångström has, however, attributed much importance to the absorption of carbonic acid gas, implying by his computation that not less than 61 percent of the solar radiation which reaches the outer layers of the earth's atmosphere is cut off by the absorption of this gas in a vertical transmission through the air. (See *Annalen der Chemie und Physik*, vol. 39, pp. 309-311, 1890.) He locates the absorption of this gas principally in the bands at  $2.6\mu$  and  $4.3\mu$ ; so that, as he says, its effect is not allowed for in the procedure for obtaining the value of the solar constant of radiation adopted by Mr. Langley in his research on Mount Whitney, and which is essentially that employed here. Ångström, while using the same method in part, adds a second term amounting to more than half the whole in his computation, solely referring to the absorption of carbonic acid gas, and thus he attains his oft-quoted result for the solar constant of radiation of 4.0 calories per square centimeter per minute. For several reasons I am inclined to think Ångström has greatly overestimated the importance of this carbonic acid absorption term: First, as he shows, the selective absorption of carbonic acid gas is, so far as I am aware, almost wholly for wave-lengths greater than  $2.5\mu$  and principally in two bands between wave-lengths  $2.5\mu$  and  $2.85\mu$  and between  $4.20\mu$  and  $4.50\mu$  respectively, where the total amount of the solar radiation is apparently less than one percent of the whole, as determined not only from the appearance of the observed bolographic solar spectrum energy curve itself, but from a consideration of the probable temperature of the sun and the distribution of energy in the spectra of bodies at high temperature. As a very evidently too great estimate of the energy in these wave-length regions, it may be seen that if the radiation outside the atmosphere (see plate XXII) was of the same intensity throughout these bands as at  $2.1\mu$ , the area they would include would be only about one-fiftieth the total area under the curves of plate XXII. It is of course very improbable that the height of the curve at  $4.3\mu$  is nearly as great as at  $2.1$ . Thus it would appear that the selective absorption of this gas for direct solar radiation is almost negligible. Second, if carbonic acid exercised a general absorption through the more intense parts of the solar spectrum, it is not apparent why such a general absorption is not included and allowed for in the coefficients of absorption here determined. Third, values of the solar constant computed here for the same day, but from observations made through very different thicknesses of air, are found to agree excellently, which appears to confirm the accuracy of the method of determining the atmospheric absorption which is here employed.

is found to be a maximum for all wave-lengths, and the height falls off as the sun declines in altitude, slowly in the infra-red region of the spectrum, but more and more rapidly as we examine further and further toward the violet, or still more rapidly if we note the great atmospheric absorption bands due to water vapor.

It is assumed that the atmospheric transmission for a very narrow portion<sup>1</sup> of spectrum may be expressed by the relation—

$$e = e_0 a^{m \frac{\beta}{\beta_0}} \quad (1)$$

where  $e$  and  $e_0$  are the intensities of light of this wave-length at the earth's surface and outside the atmospheric respectively,  $a$  the fraction transmitted by the atmosphere for zenith sun,  $m$  the air mass, or ratio of the length of the transmitting column of air to that for zenith sun, and  $\beta$  and  $\beta_0$  the observed and standard barometer readings respectively. Upon the bolograph the height  $d$  corresponding to any given wave-length is directly proportional to the amount of energy of that wave-length. Accordingly we may introduce a factor  $k$  constant for the single wave-length in question

$$d = kc = ke_0 a^{m \frac{\beta}{\beta_0}} \quad (2)$$

and hence

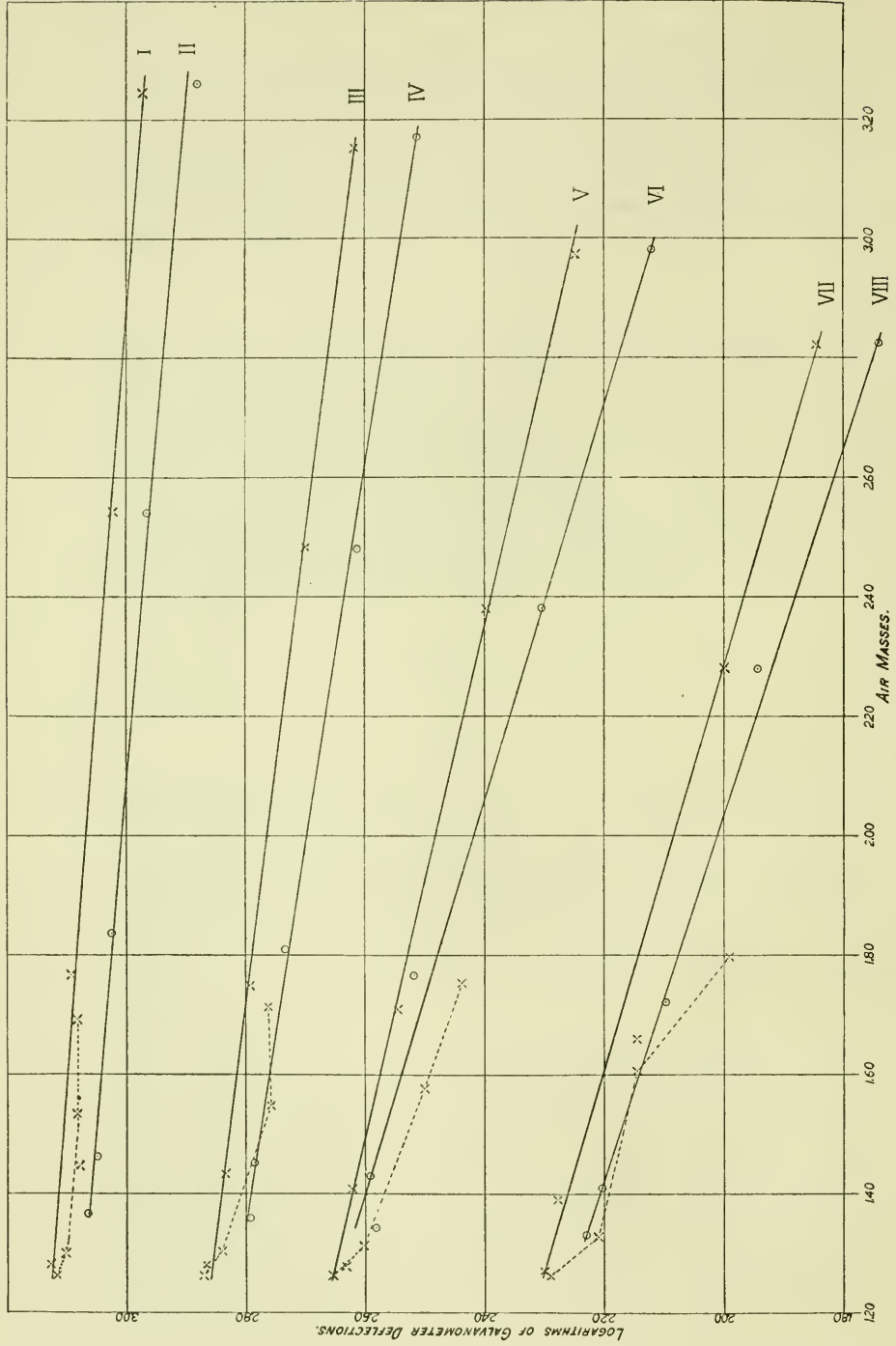
$$\log d = m \frac{\beta}{\beta_0} \log a + \log (ke_0) \quad (3)$$

As the last term of equation (3) is to be supposed constant during the day's observations, the expression is in the form of the equation of a straight line, and if the logarithms of the deflections at the given wave-length on the successive bolographs be plotted as ordinates with the quantities  $(m\beta/\beta_0)$  as abscissæ, the several points so determined should fall on a straight line of which the tangent of the inclination is the logarithm of the transmission coefficient ( $a$ ) for the given wave-length.

Mr. Langley has stated that the attempted measures of the solar constant from a station near sea-level like Washington are subject to great uncertainty from the necessity of the very large and doubtful extrapolation for atmospheric absorption. Without in the least questioning this, and while calling special attention to the great interest which would attach to a repetition of the experiments at high altitudes, I incline to the belief that the closeness with which the plotted points determined as above described lie upon a straight line for wide ranges of air mass is a reasonably sure criterion of

<sup>1</sup> In our practice less than the width between the  $D$  lines.





TRANSPARENCY OF THE ATMOSPHERE FROM BOLOGRAPHIC OBSERVATIONS.



the accuracy of the extrapolation. In order to give an impression of the weight which should be assigned to the solar constant values shortly to be given, I call attention to plate XX, which contains the plots for deducing atmospheric transmission at several wave-lengths for two days, March 25, 1903, and March 26, 1903, observations for the two days being represented by circles and crosses respectively. The tangent of the angle of inclination of the plotted lines is the logarithm of the coefficient of transparency of the atmosphere for vertical transmission of a ray of the given wave-length. Plots I and II represent a wave-length of  $1.027 \mu$ ; III and IV,  $0.656 \mu$ ; V and VI,  $0.468 \mu$ ; and VII and VIII,  $0.395 \mu$ . In connection with this branch of the subject it is well to remark what the experience of meteorologists generally no doubt confirms, that the afternoon hours are found far more uniform in transparency of the air than the morning hours, so that the observations of atmospheric transmission for use in computing values of the solar constant are obtained chiefly in the afternoon. Forenoon observations are distinguished in plate XX by being connected by dotted lines.

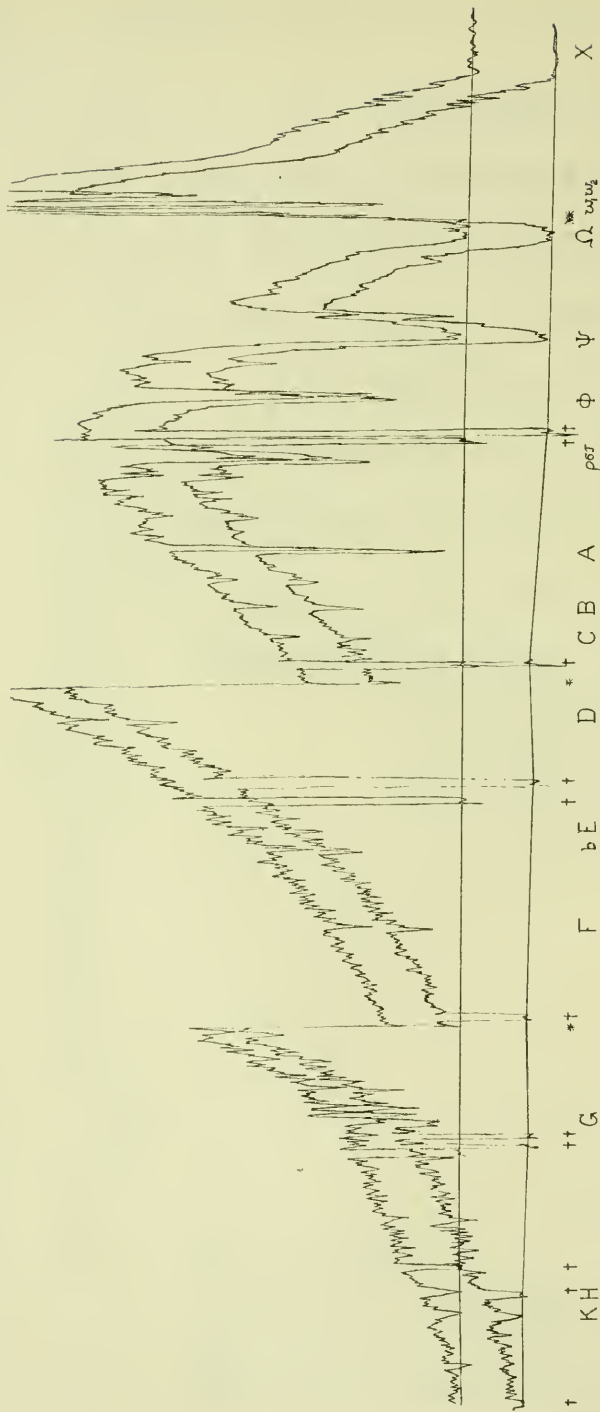
In order to fix our ideas both of the magnitude and the variability of the absorption of the earth's atmosphere, the following table, showing the percentage of transmission at numerous different wave-lengths for the days indicated, is given. The computations upon which the table is based were made at wave-lengths specially selected to avoid large terrestrial absorption bands, and thus the table gives values of the general absorption only. A few reductions have been made to determine the selective absorption within the numerous atmospheric bands of water vapor and oxygen, but while their discussion has gone far enough to show that equation (1) apparently holds good in these bands, these results are not yet far enough advanced to be included in the tables. While, as another criterion of the accuracy of the method of extrapolation, it is found, in accord with what has just been said, that the employment of these observed values of transmission within the water-vapor bands would practically fill up these bands in computations of the form of the solar energy curve outside the atmosphere, yet in determining the solar constant they are smoothed over and the general transmission constants corresponding with the smoothed curves are employed in the computation.

The days included in Table I were all nearly cloudless, and thus the results represent the transmission of the atmosphere in better than average conditions. In order to bring out clearly what seems to be a marked decrease in the transparency of the air for the present

TABLE I.  
*Coefficient of Atmospheric Transmission for Radiation from Zenith Sun.*

Wave-Length. Date.	Transmission Coefficients for Unit Air-Mass.										
	0.40 $\mu$	0.45 $\mu$	0.50 $\mu$	0.60 $\mu$	0.70 $\mu$	0.80 $\mu$	0.90 $\mu$	1.00 $\mu$	1.20 $\mu$	1.60 $\mu$	2.00 $\mu$
October 25, 1901.....			0.81	0.82	0.89	0.94		0.95	0.96	0.95	
November 2, 1901.....			0.80	0.80	0.87	0.92		0.94	0.95	0.94	
March 21, 1902.....			0.83	0.80	0.84			0.87	0.95	0.87	
May 8, 1902.....			0.89	0.77	0.90	0.94		0.95	0.94	0.91	
September 11, 1902.....			0.80	0.78	0.87	0.89	0.92	0.92	0.94	0.93	
October 9, 1902.....			0.70	0.78	0.84	0.87	0.89	0.90	0.91	0.93	
October 15, 1902.....			0.73	0.78	0.86	0.89	0.90	0.91	0.93	0.96	0.94
October 16, 1902.....			0.50	0.58	0.79	0.82	0.86	0.86	0.90	0.91	
October 22, 1902.....			0.84	0.82	0.88	0.91	0.93	0.94	0.94	0.95	
November 15, 1902.....			0.75	0.79	0.83	0.89	0.91	0.92	0.93	0.95	0.96
February 19, 1903.....	0.67	0.64	0.66	0.72	0.76	0.80	0.83	0.85	0.86	0.90	0.92
February 25, 1903.....	0.48	0.60	0.66	0.68	0.74	0.83	0.88	0.90	0.93	0.93	0.92
March 3, 1903.....	0.40	0.48	0.66	0.73	0.79	0.84	0.87	0.89	0.92	0.96	0.96
March 25, 1903.....	0.47	0.50	0.57	0.66	0.72	0.76	0.79	0.81	0.84	0.89	0.89
March 26, 1903.....	0.52	0.58	0.62	0.68	0.77	0.80	0.81	0.83	0.85	0.89	0.90
April 17, 1903.....	0.55	0.60	0.69	0.77	0.80	0.82	0.87	0.90	0.94	0.97	0.97
April 28, 1903.....	0.39	0.52	0.56	0.64	0.71	0.74	0.76	0.78	0.82	0.88	0.89
April 29, 1903.....	0.46	0.49	0.56	0.66	0.72	0.76	0.77	0.80	0.83	0.88	0.90
July 7, 1903.....	0.42	0.60	0.66	0.69	0.77	0.82	0.85	0.86	0.88	0.89	0.86
General Mean.....	0.484	0.557	0.700	0.730	0.808	0.847	0.856	0.884	0.903	0.920	0.919
Mean of 1901-2.....			0.765	0.769	0.857	0.897	0.910	0.921	0.933	0.930	0.950
Mean of 1903.....	0.484	0.557	0.627	0.692	0.753	0.797	0.825	0.847	0.874	0.909	0.912
Percentage difference between mean of 1903 and that of 1901-2.			20%	10%	13%	12%	10%	8.4%	6.5%	2.3%	4.1%





BOLOGRAPHIC ENERGY CURVES OF THE SOLAR SPECTRUM OF A 60° GLASS PRISM. OBSERVATIONS OF APRIL 17, 1903.  
 († Beam cut off by shutter to give position of zero line. \* Slit diminished by interposing grill diaphragms. \*\* Slit increased by removing grill diaphragms.)

calendar year, the means of the general absorption coefficients have been taken for the observations of 1901-02, and for those of 1903 separately. There is an average difference of ten percent in favor of the earlier years, and this cannot, so far as I know, be accounted for in any other way than by recognizing an actual decrease in the transparency of the air, beginning somewhere between November 15, 1902, and February 19, 1903. It might be urged that the change is perhaps an annual one, as most of the results of 1901-02 are in the autumn and those of 1903 in the spring. But in contradiction to this view we find the observations of March and May, 1902, generally above the mean of that year, so that I incline to think the change rather extraordinary than annual in character. Such a change would imply a corresponding reduction in the amount of direct solar radiation at the earth's surface, and if general over a wide area would seem to be likely to occasion some alteration of climate. Recent actinometric observations reported by several observers in this country and in Europe<sup>1</sup> seem to strengthen the probability that the change in transparency of the air is widespread, for their measures of solar radiation at the earth's surface have been appreciably lower of late than for the same months of former years. Several writers have suggested the possibility of the wide dissemination of fine dust clouds from the volcanic eruptions of 1902, in explanation of the lower values. It will be noted from Table I that the differences between the means of 1901-02 and 1903 are largest for short wave-lengths and diminish nearly uniformly toward the infra-red as far as a wave-length of  $1.2 \mu$ , which would probably be in harmony with this hypothesis; for such small dust particles might be expected to scatter and absorb the shorter wave-lengths most, not being large enough to act like an opaque screen diminishing all wave-lengths proportionally.

#### COMPUTATIONS OF THE SOLAR CONSTANT OF RADIATION

The coefficients of general atmospheric transmission resting upon measures at twenty-four different wave-lengths from  $0.37 \mu$  to  $2.3 \mu$  on series of bolographic curves have been employed at the Astrophysical Observatory in connection with bolographs and actinometric data to compute the solar constant of radiation outside the atmosphere. Referring to plate XXI, the area included underneath a spectral energy curve is directly proportional to the total radiation absorbed by the bolometer over the range of wave-lengths included

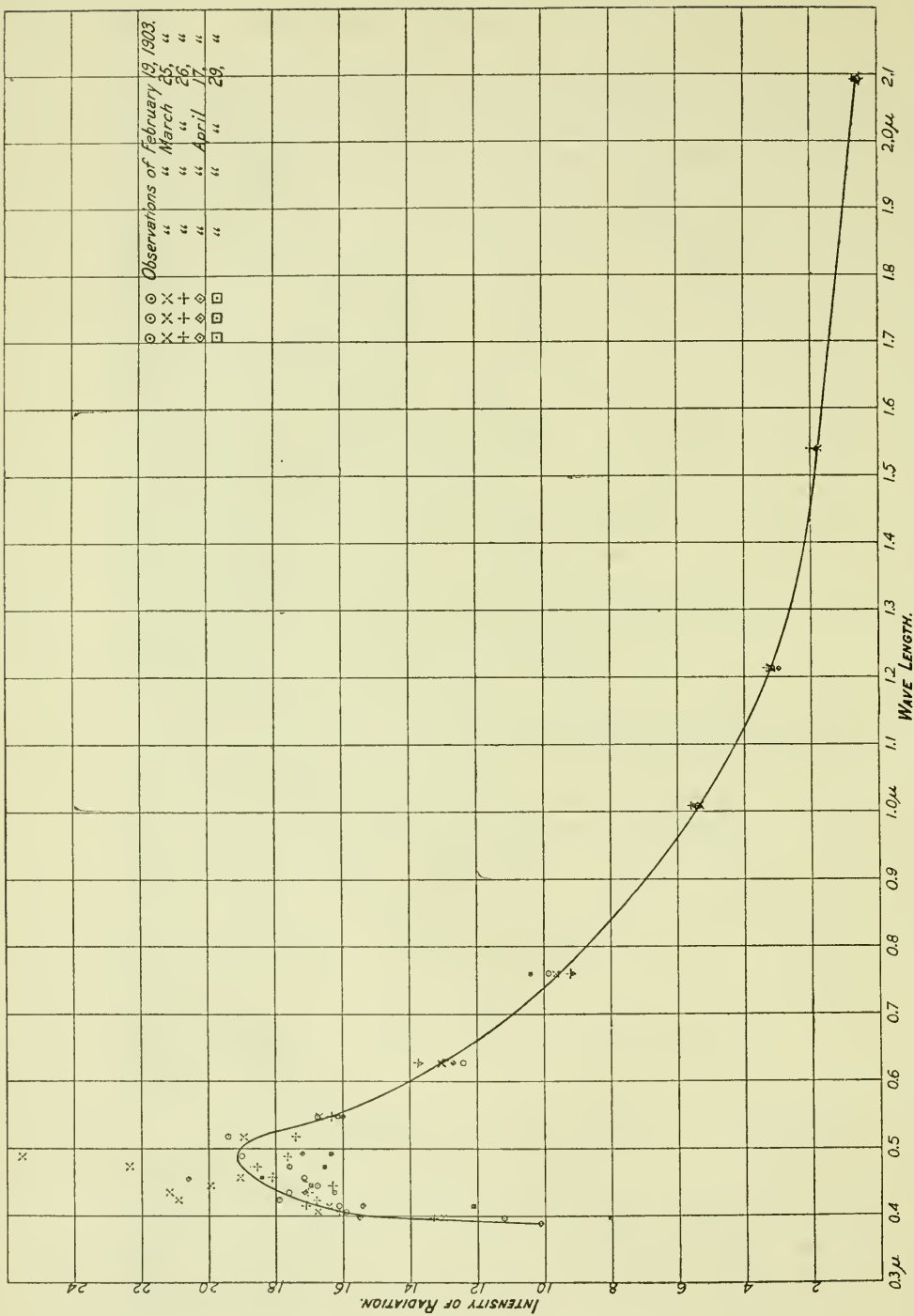
<sup>1</sup> See note by H. H. Kimball, *Monthly Weather Review*, May, 1903.

in the curve. But this area is not strictly proportional to the total solar radiation at the earth's surface, as determined by actinometer observations, for the reason that the radiation has been unequally reduced at different wave-lengths by losses at the siderostat mirror, within the spectroscope, and by selective absorption at the bolometer itself. It is necessary to correct the curve so that it shall as accurately as possible represent the distribution of energy in the solar beam prior to these losses. Inasmuch as the coefficient of total absorption of the lampblackened bolometer strip is upward of 95 percent, it is believed that no considerable error is admitted by neglecting its differences of absorption for different wave-lengths, and no correction is applied for this. The relative absorption of the spectroscope for different wave-lengths is frequently determined, and that of the siderostat mirror still more frequently, for in both these optical parts of the apparatus there is rapid deterioration of the reflecting power of the silvered glass surfaces. At present this indeed forms one of the main difficulties and sources of error of the investigation, for a whole day of observing and several days of computing are required for each determination of the absorption of the apparatus, which would be determined once and for all if constant reflecting surfaces could be employed.

With the coefficients of absorption of the apparatus thus determined, each small area included under the bolographic curve for a very narrow range of wave-lengths is increased so that the total corrected area is then proportional to the solar radiation at the earth's surface as measured with the actinometer or pyrhelimeter. Then by the aid of formula 1, given above, and employing the transmission coefficient  $a$  determined from the series of bolographs of the day, each small area is again corrected till it becomes proportional to the total radiation of that wave-length outside the atmosphere. The ratio of the sum of these finally corrected areas to the total corrected area at the earth's surface is the factor by which the reduced pyrhelimeter reading is to be multiplied to give the "solar constant" so-called.

It is evident that these values depend directly upon the pyrhelimeter or actinometer readings for their accuracy, so that these instruments become here of major importance. In the work thus far a mercury pyrhelimeter has been used as the primary standard, and the daily observations have been taken sometimes with it, sometimes with a Crova alcohol actinometer (specially constructed for the Institution under M. Crova's valued supervision), and sometimes with both instruments simultaneously. It has been shown by re-





DISTRIBUTION OF RADIATION IN THE NORMAL SOLAR SPECTRUM OUTSIDE THE EARTH'S ATMOSPHERE.



peated comparisons of the two instruments and by comparisons of the pyrheliometer with another type that they give proportional results under widely differing conditions of wind and temperature, so that I have no question of the relative accuracy of the actinometric data employed in computing values of the solar constant within two percent. There is, on the other hand, room for question as to the absolute magnitudes of the values given, for these depend on the constants and the theory of the mercury pyrheliometer. Steps are being taken to get further checks on this matter, and in a later publication it is expected to recompute the data in accord with later information. For the present then, the values in the following table are to be held as relatively accurate and consistent among themselves, but subject later to correction by a common multiplying factor.

TABLE II.  
*Values of the Solar Constant of Radiation. From Bolographic Studies.*

Date.	Hour Angle. West.	Air Mass.	Calories per Square Centimeter per Minute.		Solar Constant Corrected for Mean Distance of the Sun.
			At the Earth's Surface.	Outside the Atmosphere.	
			Cal.	Cal.	
1902. Oct. 9	0 6	1.425	1.42	2.20	2.19
" " 15	1 31	1.624	1.44	2.21	2.19
" " 22	3 01	2.415	1.20	2.18	2.16
1903. Feb. 19	1 01	1.642	1.35	2.34	2.28
" " "	2 22	2.003	1.20	2.31	2.25
" Mar. 3	0 59	1.429	1.34	2.31	2.26
" " 25	2 01	1.454	1.19	2.29	2.27
" " 26	1 57	1.438	1.16	2.11	2.10
" " "	2 59	1.754	1.05	2.09	2.07
" Apr. 17	2 45	1.463	1.19	1.97	1.99
" " 28	1 07	1.145	1.29	2.23	2.27
" " 29	2 26	1.308	1.05	1.93	1.97
General Mean.					2.167
Mean of results prior to March 26, 1903.					2.229
Mean of results after March 26, 1903.					2.080

The bolographs used in the computations extend from wave-length  $0.37\mu$  to wave-length  $2.5\mu$  with the exception of those of October, 1902, which reached only to a wave-length of  $0.48\mu$  in the violet. For these latter bolographs a correction of about twelve percent was applied, founded on the later work, and thus the results for October, 1902, are entitled to slightly less weight on this account. All the areas have been extrapolated for the radiations lying outside at both ends of the region  $0.37\mu$  to  $2.5\mu$ , but the corrections so applied amount to less than one percent altogether. Their magnitude was

determined by an inspection of the rate of decrease of successive corrected areas approaching the limits of the curves, and the corrections were checked both by computing according to Wien's formula the probable form of the solar energy curve corresponding to the assumed solar temperature of  $6000^{\circ}$ , and by examination of the normal energy curves outside the atmosphere as computed from bolographs and given in plate XXII.

I have thought it worth while to give in addition to the general mean, the means also of observations before and after March 26, when, for some unexplained reason, a fall of about 10 percent was noted in the computed solar constant. The observations of February 19,<sup>1</sup> March 25, March 26, and April 29, 1903, appear to be entitled to the greatest weight among those given, on account of the regularity of the actinometric curves of those days and the closeness with which the plotted points for determining the atmospheric transmission coefficients lie upon straight lines, as shown for two of the days in question on plate XX. Since May 1 it has been almost impossible to get sufficient observations for computing a solar constant owing to cloudiness, but interest attaches to further determinations and these are to be made when practicable.

FORM OF THE NORMAL SOLAR ENERGY SPECTRUM OUTSIDE THE  
EARTH'S ATMOSPHERE AND THE PROBABLE TEM-  
PERATURE OF THE SUN

The reader has no doubt noted that, by applying corrections for atmospheric and instrumental absorption, the bolographic spectrum energy curves may be reduced in form as well as in area to represent the distribution of energy in the spectrum of the solar beam outside the atmosphere. This has been done in several instances, and in doing so the curves have been transformed from the prismatic to the normal wave-length scale by taking account of the prismatic dispersion, and several of these curves are platted in plate XXII. No account is taken in the curves, shown in plate XXII, of selective absorption bands whether solar or terrestrial, smoothed curves only being given.

It will be noted that there is a fair agreement in general form between these independently derived curves, and that they unite in

<sup>1</sup> February 19, 1903, was the most extraordinary day as regards absence of water vapor in the atmosphere which has ever been noted here. The great water-vapor bands  $\phi/\Omega$  in the infra-red spectrum were nearly filled up, and the long wave-length side of the band  $\Omega$  presented an almost unrecognizable appearance.

fixing the wave-length of maximum energy at about  $0.49\mu$ .<sup>1</sup> Their agreement would be more exact, there can be little doubt, if it were not for the large and variable absorption of the silvered surfaces in the optical apparatus for wave-lengths at and beyond the region of maximum energy. The transmission of the spectroscope at a wave-length of  $0.45\mu$  has varied on this account at different times from 33 percent to 15 percent, whereas at wave-lengths of  $1\mu$  and thereabouts the transmission always approaches 90 percent. The spectroscope mirrors are resilvered about once in two months and the siderostat mirrors still oftener.

Paschen has empirically derived a law connecting temperature with wave-length of maximum radiation, which is expressed as follows, where  $T$  is the absolute temperature and  $\lambda_{max}$  the wave-length of maximum intensity of radiation expressed in microns:

$$\lambda_{max} T = \text{constant.}$$

The value of this constant for the radiation of a "black body" or perfect radiator as determined by Paschen,<sup>2</sup> Lummer and Pringsheim,<sup>3</sup> and others is about 2900, while for bright platinum Lummer and Pringsheim give 2630 with values for other substances intermediate between these.

Taking the higher value in connection with the observed position of maximum in the solar energy curve outside the atmosphere, we find that the sun's radiation may be assumed comparable as regards the wave-length of maximum radiation to the emission of a "black body" at  $5920^\circ$  absolute. Readers will draw their own conclusions as to the probability that the solar temperature actually lies near this value, but it may be remarked that a further correction of the energy spectrum curve for the selective absorption of the solar envelope would undoubtedly reduce the wave-length of maximum radiation still further, and would thus incline us to the view that the interior of the sun is at a higher temperature than the above considerations alone would indicate.

<sup>1</sup> The wave-length of maximum energy determined by Mr. Langley on Mount Whitney was about  $0.52\mu$ .

<sup>2</sup> *Verhandlungen d. Deutschen Phys. Ges.*, III, 37, 1901.

<sup>3</sup> Paschen, *Astrophysical Journal*, IX, 306, 1899.

# THE NEW CŒLOSTAT AND HORIZONTAL TELESCOPE OF THE ASTROPHYSICAL OBSERVATORY OF THE SMITHSONIAN INSTITUTION

By C. G. ABBOT

## INTRODUCTION

About two years ago certain observations on the absorption of the solar envelope were begun at the Astrophysical Observatory of the Institution under Mr. Langley's direction. For these experiments a solar image 40 centimeters in diameter was formed at the slit of the spectro-bolometer, and energy spectra were obtained of the radiation from the center of the disk and at points near the limb. As it is clear that the radiations coming from points more and more remote from the center must traverse greater and greater thicknesses of the solar envelope, this method of investigation offers a means of finding out something about the amount and quality of its absorption. It was hoped to determine also the nature of the energy spectrum of sun spots, but the arrangements then used proved inadequate to give sufficient steadiness and distinctness of the solar image even for satisfactory measures of the absorption of the solar envelope, to say nothing of measures on sun-spot spectra.

The apparatus used at that time for forming the solar image consisted of a large Grubb siderostat of the Foucault type giving a horizontal southerly directed beam, a nine-inch concave mirror of 2.30 meters focus, and a small convex mirror of about a meter radius of curvature placed inside the focus of the concave mirror. These latter two mirrors both had to be out of axis in order to form the image at one side of the concave mirror, and both were within the observatory, so that the beam from the siderostat passed through an aperture in the wall to reach them. With these crude arrangements it is not surprising that the solar image was in very bad and changeable focus, and subject to continual and excessive disturbance by "boiling," tremor, and bad following, besides being subject to the rotation of the field necessarily accompanying the use of the Foucault form of siderostat.

A trial of a combination of two concave mirrors of 2.30 meters and

4.70 meters focus respectively, in connection with a cælostat and second reflection from a plane mirror east of the polar axis of the cælostat, while doing away with rotation of the field, and with the chief defects in following, still furnished a very poor image, subject to changes of focus of ten feet between full and cloudy sunlight, and attended with serious "boiling," which was not at all reduced by providing a canvas tube for the beam, but which did diminish when the sky was very thick with cirrus clouds or haze.

It was thought best to arrange to cast the image to its full size of forty centimeters by means of a single concave mirror, but before ordering this, Mr. Langley, following his well-approved policy of trying a new thing on a small scale, first procured a five-inch mirror of forty feet focus, and directed that this should be set up for a preliminary trial. Recognizing that the "boiling" (or fluttering confusion of all parts of the image due to variability of the strata of air traversed by the beam) would probably prove the main obstacle to forming a well-defined solar image, he devised and directed a novel experiment of "churning" the column of air traversed by the beam. This experiment was made with a very satisfactory result as described by Mr. Langley in his article on *Good Seeing*,<sup>1</sup> and with more detail as regards apparatus in the appendix to the administrative report of the Secretary of the Smithsonian Institution for the year ending June 30, 1902.

In brief it appeared that "boiling" caused within the telescope tube itself could be entirely removed by churning the air, and that for high sun a churned tube pointing toward the sun and reaching forty feet above the surface of the ground sufficed to overcome the main portion of the prejudicial disturbances of the air, so that the remaining "boiling" of the solar image did comparatively little harm to the definition. It was observed with the forty-foot focus telescope that the vigorous churning of the air seemed to decrease those changes of focus with varying cloudiness which had been noted in the earlier work, and which were observed also with the forty-foot focus instrument when the stirring apparatus was stopped. Among the incidental advantages of the stirring may also be included the more rapid convection of the heat of absorption of the solar beam at the mirror surfaces, and consequent diminution of the alteration of figure which is always caused by unequal heating of glass mirrors. In the preliminary tests it was found that the stirring apparatus communicated vibrations to the ground sufficiently serious to produce a prejudicial tremor of the image, but it was noted that the pass-

<sup>1</sup> *American Journal of Science*, February, 1903.

ing of heavy wagons produced almost as great, though intermittent, tremor, so that it appeared that very good piers would be necessary even if no stirring was contemplated.

#### LONG FOCUS HORIZONTAL TELESCOPE

A mirror of 50 centimeters aperture and 40 meters focus was ordered from the J. A. Brashear Company, and it was decided to instal this as a horizontal telescope lying in a north and south direction, to be fed by a cœlostat or siderostat as seemed most desirable.

It was deemed necessary to provide heavy and deep-founded piers for the cœlostat and image-forming mirror, and although it was not indispensable for the work immediately in view that the pier where the image was formed should be as free from tremor as the others, it was deemed best to make the three piers alike, to provide for possible contingencies. For each pier a pit was dug twelve feet square and ten feet deep, and the four sides of the pit were supported by walls of pebble and cement one foot thick. At the bottom of the cubical cavity remaining was filled in twenty-four inches of sand, and on this a twenty four-inch base of pebble and cement with a clear space of six inches all round between it and the walls of the pit. On this base was erected to the surface of the ground a hollow brick pier, with eighteen-inch walls on four sides, and a thirteen-inch wall across the center. A cap-stone eight feet long, seven feet wide, and seven inches thick completed each pier, except that for the cœlostat (finally decided upon) a superstructure of brick was provided.

#### THE CŒLOSTAT

The cœlostat consists essentially, as is well known, of a plane mirror fixed parallel to a polar axis which turns uniformly at the rate of one rotation in forty-eight hours. An instrument of this kind was described and illustrated in an article by Von Littrow<sup>1</sup> in 1863, but he ascribes the principle to August, who appears to have discovered it about thirty years earlier. It is surprising that so simple and excellent a device did not come into general use sooner, but though rediscovered and employed for a time about 1880 by Mr. Langley at Allegheny, and very likely also by others, it has been only within the last five years that the cœlostat has become generally known and used. Its chief merit, besides simplicity and consequent accuracy of driving, is the fact that the whole field of view remains fixed, whereas in other forms of siderostats and heliostats one point only of the re-

<sup>1</sup> *Wein. ber.*, XLVIII, II, pp. 337-348, 1863.

flected beam is fixed, and about this point all other parts of the field revolve, either with uniform or (as in the Foucault form) with a velocity variable according to the position of the heavenly body. To counterbalance these advantages the cœlostat does not in its simplest form send the beam in a fixed direction independent of the declination, but when used, as is customary, to give a horizontal beam, this beam deviates toward the north of an east and west line for objects south of the celestial equator and vice versa. Furthermore, when sending a horizontal beam nearly eastward horizontally, it is clear that the mirror is employed at a very unfavorable angle for objects near the western horizon.

It had been proposed here to get over these two disadvantages by the use of a second plane mirror, itself mounted so as to permit of moving it upon a U-shaped track with north and south branches close to and on the east and west respectively of the polar axis carrying the first or rotating mirror, which latter was intended to cast its beam nearly horizontally to the east in the morning and toward the west in the afternoon. This device was tried, but there were serious objections to it, the chief one being that for objects far south and near the meridian (like the sun at noon in December) the cross-section of the reflected beam was very small compared with the aperture of the first mirror.

#### IMPROVED FORM OF TWO-MIRROR CŒLOSTAT

Fortunately a better device for solar work at this latitude was then thought of. This consists in reflecting the beam due south from the rotating mirror and thence due north from the second mirror over the top of the first. The beam from the first mirror shoots upward at an angle with the vertical equal to the sum of the angles of latitude and declination; and for the sun at Washington this angle is about  $62^\circ$  at summer solstice and  $16^\circ$  at winter solstice. Therefore to give a horizontal northerly directed beam the second mirror is to be inclined forward  $14^\circ$  at the former period and  $37^\circ$  at the latter.<sup>1</sup> In the following table is given the diameter of mirrors for this form of cœlostat and for other instruments to furnish a fixed horizontal north and south solar beam at the latitude of Washing-

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<sup>1</sup> If it was necessary to incline the second mirror forward still more, a special support would be required; but it seems unquestionable that the Ritchey support system (*Astrophysical Journal*, v, 143, 1897), modified only so far as that the mirror is stuck by cement or by exhaustion of the air to the numerous balanced supporting pieces, would be quite as efficient here as for the usual case of a mirror reclining face upward.

ton and for different times of the year and day. It will be seen that in economy of mirror surface the cœlostat thus arranged has the advantage. In this form of cœlostat the moving mirror is never used in very different positions, so that owing to the consequent probable constancy of figure in the mirror it seems to be well suited to long exposures in stellar photography.

*Comparative Sizes of Mirrors Required to Furnish a 20-inch Horizontal North and South Beam from the Sun at Washington. (Latitude 38° 53'.)*

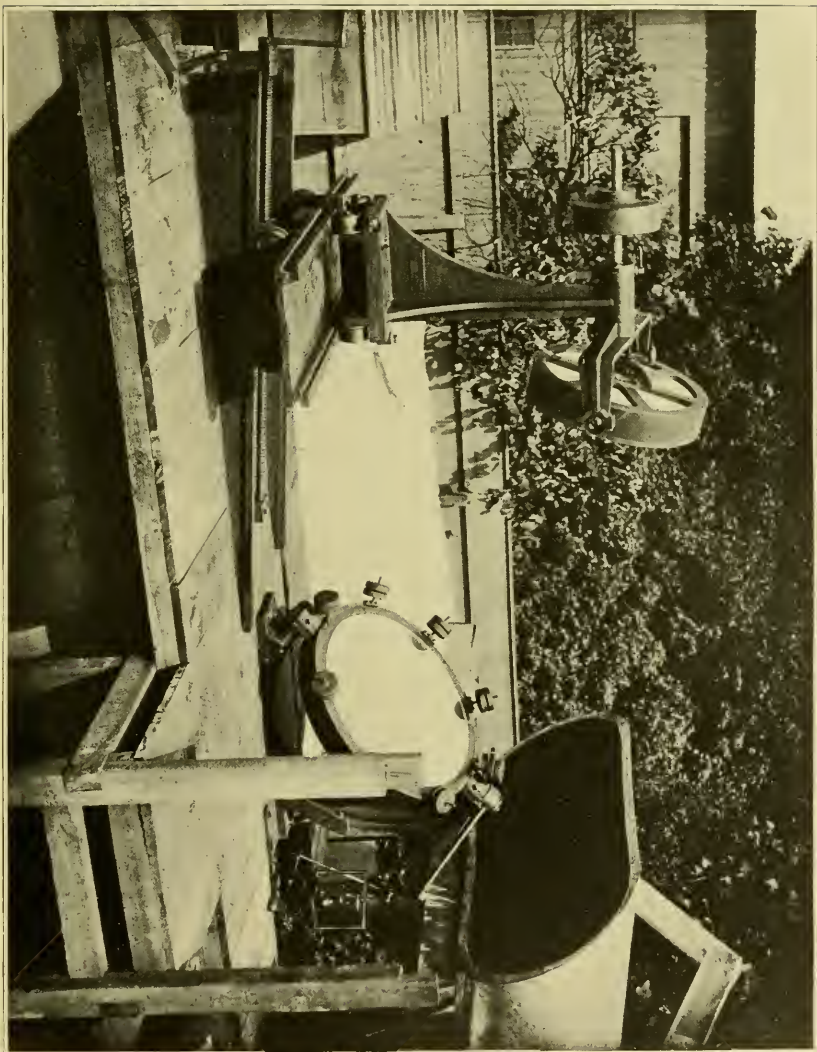
Day.	Hour.	Two Mirror Cœlostat. First Mirror Reflects South. Second North.		Two Mirror Polar Siderostat First Mirror Reflects North. Second South.		Foucault Single Mirror Sidero- stat Sending Beam South.
		Diameter First Mirror.	Diameter Second Mirror.	Diameter First Mirror.	Diameter Second Mirror.	
June 21	7 A. M.	27.4 in.	20.6 in.	23.8 in.	21.2 in.	31 in.
	9 A. M.	23.6	20.6	23.8	21.2	27
Sept. 21	12 M.	21.8	20.6	23.8	21.2	25.2
	7 A. M.	25.2	22.2	28.2	21.2	26.2
	9 A. M.	21.6	22.2	28.2	21.2	23.4
Dec. 21	12 M.	20.0	22.2	28.2	21.2	22.2
	7 A. M.	27.4	25.6	36.4	21.2	23.4
	9 A. M.	23.6	25.6	36.4	21.2	21.6
	12 A. M.	21.8	25.6	36.4	21.2	20.6

It will be noted that at noon of the equinoxes the second mirror if exactly south of the first would cut off the beam, and that at summer solstice it must be further south than in winter to reflect the beam clear over the first mirror. Accordingly the second mirror is provided with a carriage and two pairs of tracks at right angles like the slide rest of a lathe, so that the mirror may be displaced to the west a little before noon when the sun is in its southern declinations, and can be shifted back to the east a little after noon.<sup>1</sup> The north and south track is for the purpose of shifting the second mirror for different declinations of the sun, the mirror being at the south end of the track at the summer solstice.

As it has been thought that this solution of the difficulties attending the use of the cœlostat will prove of interest and value to astronomers, a large instrument of this type was ordered from the J. A. Brashear Company for exhibition at the Louisiana Purchase Exposition to be held next year at St. Louis. Plate XXIII is from a photograph of this cœlostat as now being tested at the Astrophysical Ob-

<sup>1</sup> With a small instrument of this type it might be more desirable to move the first mirror and driving mechanism on an east and west track for this purpose, but this is not provided for in the large cœlostat about to be described.





THE LARGE CCELOSTAT WITH SECOND MIRROR, SMITHSONIAN ASTROPHYSICAL OBSERVATORY.



servatory, in connection with the long-focus mirror above mentioned. There is also shown in the illustration a portion of the "churned" tube of the horizontal telescope, of which more will be said later. The cœlostát carries a thirty-inch and a twenty-five-inch mirror, the former turned by a polar axis driven at the rate of one complete rotation in forty-eight hours, the latter mounted on a carriage with traverse motions at right angles like the slide rest of a lathe. The cell of the second mirror is carried by trunnions in a fork itself capable of turning about a horizontal north and south axis, and by these two motions of rotation, with their fine adjustments, the beam may be sent in any direction whatever, though most favorably in a nearly northerly one. In actual use the reflected beam is depressed about  $6^\circ$  from the horizontal to feed the long-focus mirror,<sup>1</sup> which is 55 feet north and about  $3\frac{1}{2}$  feet below the center of the first mirror of the cœlostát, directly under which the beam passes toward a focus on the third pier, some 85 feet further south. To provide for this depression of the beam from the horizontal, the north and south, or declination, track of the cœlostát is inclined upward at a corresponding angle, so that the reflected beam may always clear the first mirror. The length of travel of the lower base of the second mirror on this north and south track is five feet and the lower base itself has an east and west track six feet long on which the upper casting is moved to and fro to allow for avoiding the shading of the main cœlostát mirror by the cell of the twenty-five-inch mirror between 11 o'clock and 1 o'clock near the times of the equinoxes.

#### THE TUBE AND STIRRING DEVICE

Early experiments on an artificial star with the long-focus mirror, before the completion of the cœlostát or the installation of a tube, showed conclusively that the "boiling" caused by irregularities of the atmosphere over the grass-grown soil between the mirror and its focus was far too great to permit anything like satisfactory definition on the solar image, and therefore the novel device of a tube with provision for stirring the air by means of a blast was ordered. It consists of a main horizontal tube 24 inches in internal diameter with diaphragms at five-foot intervals, and with

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<sup>1</sup> If the telescope was intended for stellar or lunar photography it would not be allowable to use the concave mirror quite so far out of axis as the  $3^\circ$  thus required; but the deformation of images from this cause, as computed by the formula of Poor (*Astrophysical Journal*, VII, 120, 1898) for the long-focus mirror is only about  $0''.25$  of arc, which is inappreciable compared with other defects of solar definition.

an inclined flared tube uniting with the main tube at the north end close in front of the concave mirror. At intervals of about five feet, five-inch ducts lead to air-mains 14 inches in diameter, which in turn at length unite in two twenty-inch mains leading to the intake and blast respectively of a twenty-nine-inch fan blower with direct connected  $2\frac{1}{2}$  horsepower electric motor. It is so arranged that the openings in the telescope tube communicate with the blast and suction of the blower alternately, so that the air within the tube is repeatedly carried through the system and churned over and over. Thus the path of the beam from the cœlostat to the focus of the mirrors is thoroughly stirred, but nothing has been done as yet to introduce stirring between the cœlostat and the sun. It is possible that an attempt will be made later to stir the path of the beam in the eighty feet immediately above the cœlostat, if it is found impossible to get good enough definition with the present arrangements.

It should be recalled that the conditions required for bolometric work are quite different from those suited to direct eye vision or to photography. Bolometric studies require unchanging transparency of the air, else difference in the galvanometer deflection may be due to alterations in transparency of the intervening medium and not to the properties of the source of light. Thus those times when thin cirrus clouds, fog, or smoke cover the sun, which are well known by solar observers to be the times when "boiling" is apt to be diminished, and which are the most favorable opportunities for visual and photographic observations, are quite unsuitable for bolometric work. Indeed the best time for this is somewhat after noon on those clear October days when "boiling" is apt to be at a maximum, but cloudiness at a minimum, and it is probable that the definition obtained in such conditions will never be the best.

Trials made thus far have demonstrated the great value of the stirring apparatus, not only to diminish "boiling," but to preserve a constant focal length and tolerable definition. "Boiling" is still of course noticeable, because the long reach of air above the cœlostat is not stirred, but the image is far better than could be obtained with the earlier appliances, and owing to the massive piers and to the simplicity of driving mechanism it is less subject to jars and wandering.

In later communications it is expected to describe bolometric work upon the solar image formed by the great horizontal telescope.

ON SOME PHOTOGRAPHS OF LIVING FINBACK  
WHALES FROM NEWFOUNDLAND

BY FREDERICK W. TRUE

It is only within recent years that works upon cetaceans have been illustrated with reproductions of photographs from nature. Earlier writers had to content themselves with drawings, and as these were quite commonly the work of unskilled hands, they were often extremely inaccurate, or even positively worthless as illustrations. From lack of knowledge the artist was usually unable to interpret the form of the various parts of the animal before him and consequently introduced features and combinations which had no counterpart in nature.

As photography improved, opportunities were taken to obtain photographs of skeletons, of dead whales lying on the beach, etc., upon the study of which conclusions could be based without great risk of error. All the earlier photographic pictures of whales, however, represented dead animals, and not unfrequently such as were in a more or less advanced stage of decomposition, whereby a life-like appearance was entirely lost. Photographic representations of living whales were still, therefore, a desideratum. Within the last four or five years some such photographs have been obtained, and the purpose at this time is to describe those which the writer made in Newfoundland in 1899. The only others with which I am acquainted are those taken by Dr. Racovitza and Dr. Cook in the Antarctic Ocean in 1898 and published a few months ago among the results of the voyage of the *Belgica*. My own photographs are, I believe, the only ones representing living whales in American waters thus far published.

They were taken from the bow of the whaling steamer *Cabot*, belonging to the Cabot Steam Whaling Company, while engaged in chasing whales in the unquiet waters of Notre Dame Bay, Newfoundland. They all represent the common finback, *Balænoptera physalus* (L.), and all the individuals were in motion.

Mr. Aldrich, writing of the Arctic right whale, very justly remarks: "It is disappointing to see a whale, for most pictures represent him as standing up like a buoy, or posing on his tail on the top

of the water. The real fact is that only the top of the head and a small piece of the back are seen and perhaps the 'flukes,' or, in common English, the tail, may take an occasional sweep in the air." It is much the same with the Newfoundland finbacks. Seen alive in their native element they presented to the eye only a slight hint of that graceful form which was revealed when they were drawn out on the slip at the whaling station. Still, the part seen was that of a living animal, and therefore was possessed of a separate interest from the dead specimens on the slip. While the photographs show little of the whale's form, they do represent with accuracy their appearance in their natural environment, and also give some idea of their actions and attitudes while swimming.

Among whales, as among other animals, some actions and movements are habitual and characteristic, while others are unusual and are repeated only at long intervals or under peculiar circumstances. Nearly all observers who have had frequent opportunities of observing whales agree that many species, such as the humpbacks, indulge at times in strange antics, such as leaping entirely out of the water, rolling from side to side, taking a vertical position, with the head up or the tail up, as the case may be. While the Newfoundland finbacks may, and probably do, engage in such performances, nothing of the kind occurred during my observation of them. They appeared singly or by twos or threes, spouting at irregular intervals, but pursuing a quite regular course in a definite direction for a considerable distance. They came up to the surface obliquely to spout, and the top of the head became visible, but was not elevated perceptibly above the waves. Then the head sank down, the back came into view gradually from the shoulders backward, exhibiting a strong curvature, and finally the dorsal fin appeared, but little or nothing beyond. The flukes were not to be seen in any instance, nor the pectorals, nor the eye, nor any of the underparts.

The photographs show a number of details not noted at the time they were taken. Indeed, the difficulty of getting the picture itself is so great that one's faculties are entirely absorbed in the proceeding and there is little opportunity for observing particulars. The pitching and rolling of the steamer in the restless waters is very disconcerting, and not less so the fact that the point at which the whale will appear is uncertain and the length of time it will remain in view very brief. I will now describe the several photographs which are here reproduced. Others were taken, but are less satisfactory or less characteristic.

Plate xxiv, 1, shows a very characteristic appearance of a finback



1. Preparing to descend.



2. Just reaching the surface.

LIVING FINBACK WHALES.

(*Balenoptera physalus* L.)







1. After spouting.



2. Similar attitude, nearer view.



3. Posterior view.

LIVING FINBACK WHALES.  
(*Balænoptera physalus* L.)





1 Ready to descend.



2 Process of descending—head under water, back arched.

LIVING FINBACK WHALES.

(*Balænoptera physalus* L.)



as it courses along at the surface. The whale has spouted and is preparing to descend. It will be noted that the entire head is below water; the back is slightly arched and the dorsal fin is distinctly in view above the surface, though the water is breaking over it in front. The flukes are invisible and make no disturbance of the surface of the water. Nothing is seen of the pectoral fins.

Plate xxiv, 2, represents a finback that has just come to the surface to spout, or has just completed that act. The top of the head is out of water and slightly inclined upward. The blowholes are seen as a dark eminence, and all about the head is a white rim of foam. There is an appearance on the right side as of the mandible projecting laterally beyond the upper jaw, but this is probably an illusion due to the waves.

In plate xxv, 1, is shown a finback in a similar position, but there is no doubt in this case that the whale has spouted. Its vapory breath forms part of the haze at the left of the head. The whole upper surface of the body from about the middle of the head to the dorsal fin is above water and the blowholes are distinctly marked by a dark eminence near the left end. The dorsal fin is not visible, but would have soon appeared. A very remarkable feature of this view is the great height of the eminences at the sides of the blowholes. The apertures themselves are situated between elevations, but in the dead whales on the slip these eminences present no such apparent height as here shown. This photograph and the next lend some support to the view advanced by Buchet and Racovitza that the whales project the blowholes outward when spouting. Racovitza's photographs, however, while admirable in other respects, and extremely interesting, do not show the region of the blowholes distinctly enough to throw much light on the point in question, and his sketches are rather unintelligible, and in some cases (*e. g.*, plate 3, figs. 14, 15, etc.) certainly incorrect. It would appear, at all events, that the eminences at the sides of the blowholes are raised when the whale is spouting, rather than the blowholes themselves.

Plate xxv, 2, shows a finback in an attitude similar to the last, but the animal is nearer. In this the ridges on the sides of the blowholes are extremely prominent and clearly defined. The anterior end of the head is hidden, but the line of the back is visible to the dorsal fin, over which the waves are breaking. Even beyond the fin the dorsal line is to be seen, but is not well defined.

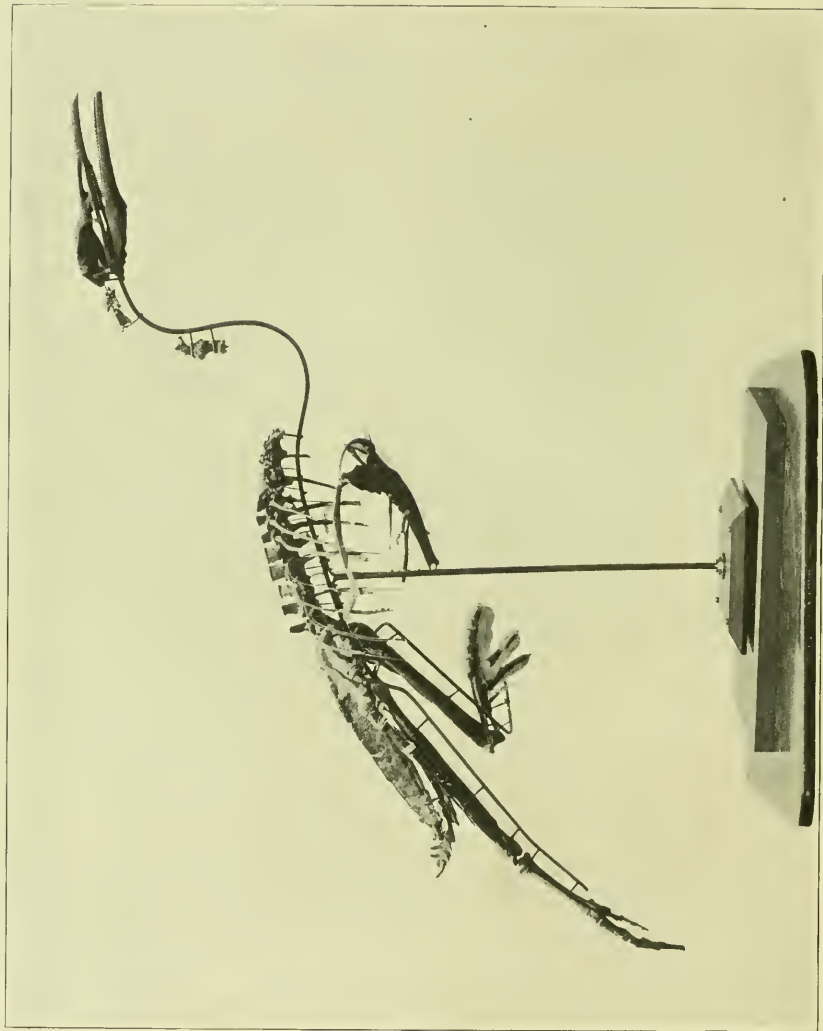
Plate xxv, 3, is a rather indistinct view of one of these finbacks from the posterior end. It shows the great breadth of the back. The blowholes appear as black spots at the interior end of the figure, and the dorsal fin, with foam about it, at the posterior end.

In plate XXVI, 1, is shown a finback ready to descend. The head has already disappeared, the back is quite strongly arched, and the dorsal fin is very distinct and entirely above water. As in the other views nothing is seen of the flukes.

The finback shown in plate XXVI, 2, has the head much farther down in the water and the back very strongly arched. The dorsal fin is visible, but is partially submerged. Here again the flukes are invisible.

These photographs and the notes, which I made while on the whaling steamer, are in agreement with the observations of Packard, Scammon, Pechuel, Cocks, Balfour, and Rawitz on the same species and its close ally (which may, indeed, be identical with it) in the Pacific. All agree that under ordinary circumstances the finback rises and sounds obliquely, that the flukes are not thrown out, that the spout is vertical, and that the actions of the animal as regards the length of time it remains below the surface, the distance it travels while submerged, and the number of times it spouts in succession, are irregular. Pechuel held that the spout was double, but my observations agree with those of Packard, Rawitz, and Racovitza, that the spout is single in the finbacks. The vapor-laden breath in all whalebone whales escapes, of course, from two separate apertures, but in the common finback, at least, the two columns unite so close to the head that they appear as one.





SKELETON OF HESPERORNIS IN THE U. S. NATIONAL MUSEUM.



## A SKELETON OF HESPERORNIS

By FREDERIC A. LUCAS

The announcement by Professor Marsh of the discovery of birds with teeth in the chalk-beds of western Kansas was not only important from a scientific standpoint, but aroused much popular interest. Unfortunately, toothed birds are not merely rare but usually are in a more or less imperfect condition; the teeth, too, are so small and so few remain in the jaws that a specimen of a toothed bird is apt to prove a disappointment to the few who see them. In this last particular the example of *Hesperornis regalis* (plate XXVII), which formed a portion of the exhibit of the U. S. National Museum at the Buffalo Exposition, is no exception to the general rule; it is, however, one of the most complete specimens yet discovered, being the first sufficiently well preserved to admit of its being mounted. The mounting of this specimen revealed the fact that in the position of its legs *Hesperornis* was not only different from any modern bird, but different from all other birds. In ordinary waterfowl, such as ducks and geese, the legs, when swimming, are beneath the body, and this is also the case in such highly specialized divers as loons and grebes, in which the legs are placed far back. But in *Hesperornis* the articulations of the leg-bones were such as to show that in swimming the legs must have stood out, almost at right angles to the body, suggestive of a pair of oars. This also suggests that the legs, like oars, may have been moved together and not alternately, since an alternate motion of the legs would have had a tendency to throw the body from side to side. It is a little difficult to see just what advantage could be derived from such a method of swimming unless it was for rapid movement at the surface. This peculiar position of the legs was not found in the Cretaceous diver *Baptornis*, also from western Kansas, in which the legs were situated as is customarily the case.

The present specimen of *Hesperornis* also showed that in the structure of its shoulder girdle the Cretaceous bird was more like modern birds than heretofore supposed. These details will be found described in the *Proceedings* of the U. S. National Museum for 1903, pp. 545-552.

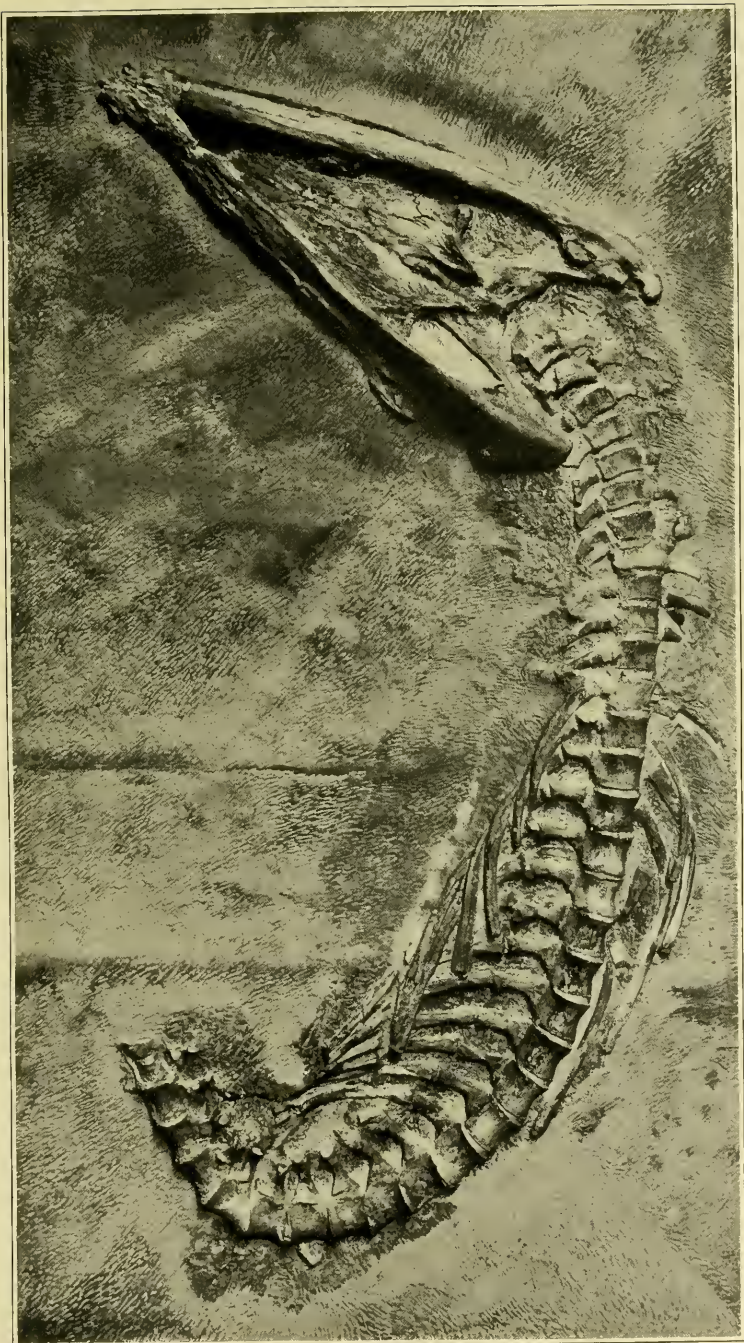
## A NEW PLESIOSAUR

By FREDERIC A. LUCAS

Among the specimens included in the Marsh collection was a fine example of a plesiosaur which has recently been described by Dr. S. W. Williston<sup>1</sup> under the name of *Brachanchenias lucasi*. The specimen, which lies on its back, comprises the skull and jaws, with thirty-five consecutive vertebræ (plate xxviii). The upper portions of the skull and vertebræ were unfortunately weathered away before the discovery of the animal, which was found near Delphos, Ottawa county, Kansas. While the popular idea of a plesiosaur, derived from the graphic descriptions of English writers, is that of a reptile with a long, snake-like neck, yet many short-necked animals are included under that term. The present individual enjoys the distinction of being the shortest necked species yet discovered, and this, coupled with the massive head, causes the specimen to suggest a crocodile, the more that the large swimming paddles were unfortunately not preserved, having been washed away before the specimen became entombed in the deposits forming the Fort Benton limestone. Dr. Williston calls attention to the fact that while plesiosaurs are not at all uncommon in the Cretaceous deposits of North America, they are for the most part represented by detached bones, or at the best isolated, if well-preserved paddles. So while thirty-two species and fifteen genera have been described from the United States, in not a single one has any considerable portion of the skeleton been preserved, aside from those that have been described by Dr. Williston himself, and the skull is known in but three instances. As the present example shows the bones of the under side of the skull very clearly it is of special importance.

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<sup>1</sup>"North American Plesiosaurs," part 1; *Field Columbian Museum, Publication 73, Geological Series*, vol. II, No. 1; Chicago, April, 1903, p. 57.



INCOMPLETE SKELETON OF PLESIOSAUR IN THE U. S. NATIONAL MUSEUM. TYPE OF BRACHANCHENIUS LUGASI WILDLISTON.







SHELL GORGET WITH ENGRAVED FIGURE OF A DISCUS THROWER, FROM AN ANCIENT GRAVE NEAR EDDYVILLE, KENTUCKY. (Diameter, 5 inches.)

## SHELL ORNAMENTS FROM KENTUCKY AND MEXICO

By W. H. HOLMES

Among the many interesting relics obtained from mounds and burial places in the Mississippi Valley are the engraved shell gorgets, a number of which are now preserved in our museums. The most recent addition to this class of objects was obtained by the National Museum from Mr. C. A. Nelson of Eddyville, Lyon County, Kentucky, and comes from a burial place encountered in opening a stone-quarry near Eddyville. It is a symmetric saucer-shaped gorget (plate XXIX) five inches in diameter and made apparently from the expanded lip of a conch shell (*Busycon perversum*). It is unusually well preserved, both faces retaining something of the original high polish of the ornament. Two perforations placed near the margin served as a means of suspension. The back or convex side is quite plain, while the face is occupied by the engraving of a human figure which extends entirely across the disk. It will be seen by reference to the illustration that this figure is practically identical in many respects with others already published.<sup>1</sup> It is executed in firmly incised lines and is partially inclosed by a border of nine concentric lines. The position of the figure is that of a discus thrower. The right hand holds a discoidal object, the arm being thrown back as if in the act of casting the disk. The left hand extends outward to the margin of the shell and firmly grasps a wand-like object having plumes attached at the upper end, the lower end being peculiarly marked, and bent inward across the border lines. The face is turned to the left; the right knee is bent and rests on the ground, while the left foot is set forward as it would be in the act of casting the disk. The features are boldly outlined; the eye is diamond shaped, as is usual in the delineations of this character in the mound region. A crest or crown representing the hair surmounts the head; the lower lobe of the ear contains a disk from which falls a long pendent ornament, and three lines representing paint or tattoo marks extend across the cheek from the ear to the mouth. A bead necklace hangs down over the chest and the legs and arms have encircling ornaments. The lower part of the body is covered with an apron-like garment attached to the waistband, and over this hangs what appears to be a

<sup>1</sup> Holmes in *Second Annual Report Bureau of Ethnology*, pl. lxxiii.

pouch with pendent ornaments. The moccasins are of the usual Indian type and are well delineated. A study of this figure strongly suggests the idea that it must represent a disk thrower engaged, possibly, in playing the well-known game of chungkee.

Reference has occasionally been made to more or less well-defined analogies existing between the shell gorget engravings of the Mississippi Valley and similar designs from Mexican engraved gorgets and others occurring in various ancient manuscript books. The resemblances are indeed striking and deserve the attention of archaeologists. In plate xxx is presented an engraved gorget obtained in Mexico, probably in the state of Guerrero, and now owned by the Field Columbian Museum, Chicago, which will serve to illustrate the resemblances and the differences in the delineations of the two regions. The discoidal gorget is the most common form in both Mexico and the United States; but this specimen is oblong, being wide above and narrow below, conforming in a measure to the tapering form of the lip of the shell from which it was carved. The gorget is rather roughly worked out and the upper margin has been perforated for suspension, but two of the perforations have been broken away. These perforations are in the plain border which surrounds the design, but there are seven additional holes within the engraved surface; these may also have served for attaching the ornament to a garment. The human figure, engraved in rather crudely executed lines, faces to the left; the right knee is bent as in the Kentucky specimen, and the left leg extends forward. The position of the arms is not readily made out, owing to the cramped position imposed by the contracted space. What appears to be the left hand, supplied with an enormous thumb, rests against the right border of the design and grasps some kind of an implement pointed downward. The right hand extends in front of the figure against the left border and is partly broken away; it appears to have grasped a staff terminating in what may be a rattle or possibly a symbolic device such as is often seen in ancient Mexican drawings. The mask-like features of the personage are drawn with the usual boldness of the Mexican work, and the eye is a conical depression surrounded by a curved line the ends of which open backward. The lower part of the face is covered with several groups of straight lines and a row of large teeth is shown. The ear and the ear disk are almost identical with corresponding features of the Kentucky specimen already shown. The somewhat elaborate headdress is well engraved, and the body and legs are covered with markings representing costume. At the waist there is a belt, and the legs show encircling ornaments and indentations suggesting buttons. The de-







SHELL GORGET FROM MEXICO WITH ENGRAVED HUMAN FIGURE  
(Length,  $6\frac{1}{2}$  inches.)

vices occupying the space beneath the human figure are carefully drawn but are so crowded together as to make interpretation difficult.

These objects are presented here not that any discussion is to be based upon them but rather for the convenience of students engaged in comparative studies of the native art of the various regions. A comparison of these with two other recently described specimens will prove interesting.<sup>1</sup>

It may not be amiss to present in this place a somewhat remarkable design engraved on a thin piece of dark wood or bark which is about three and one-half inches in width and five and one-half inches in length (figure 2). It was obtained from "a mound seven miles inland, opposite Sheffield, Alabama," and belongs to a collection obtained by the Field Columbian Museum from Mr. C. W. Riggs. The excellent state of preservation shown by this fragile specimen is due to association with objects of copper. The design includes a border three-fourths of an inch in width filled in with obliquely placed oval figures with central depressions, alternating with obliquely placed straight lines—the whole combination suggesting a current scroll. Within this border is the boldly drawn figure of a giant spider, the spaces on the ground being filled in with incised lines running at various angles. The treatment of the insect is highly conventional, but the character is well preserved. The resemblance of this example to certain delineations of spiders engraved on shell gorgets found in various parts of the same general region is very marked.



FIG. 2.—Spider engraved on a bark tablet from an ancient grave near Florence, Alabama. (Length  $5\frac{1}{2}$  in.)

<sup>1</sup>M. H. Saville: "A Shell Gorget from Huasteca, Mexico"; *Bulletin American Museum*, vol. XIII, p. 99. F. Starr, "A Shell Gorget from Mexico"; *Proceedings Davenport Academy*, vol. VI, p. 173.

# ON THE GLACIAL POTHOLE IN THE NATIONAL MUSEUM

By GEORGE P. MERRILL

For several years the department of geology of the National Museum was on the lookout for a desirable object of the nature indicated by the above title and of such dimensions and so situated as to allow its removal and installation in the National Museum. In the summer of 1884 the one finally obtained was "located," but it was not until 1892 that conditions favored the attempt to remove it. The supervision of the work was entrusted to Dr. O. C. Farrington, to whom I am indebted for the account of its extraction given below. The rock in which the pothole occurs is a gray, white-banded, strongly foliated, micaceous gneiss, standing nearly on edge, with the hole eroded parallel with the foliation. These features are shown in the accompanying illustration (plate XXXI). It is scarcely necessary to state that the parallel flutings on the outside of the block were caused by the drills during the process of extraction. Although somewhat shattered by the jar of blasting, as stated by Dr. Farrington, the injury was easily remedied by a little cement, and the specimen as it stands to-day is one of the most striking in the department. The total weight of the specimen is about 4000 pounds.

Following is a transcript of the label :

## GLACIAL POTHOLE

Riggsville Landing, Georgetown, Maine, 60,880. Collected for the Museum under the direction of O. C. Farrington. 1893.

" Besides its proper and characteristic rock erosion, a glacier is aided in a singular way by the coöperation of running water. Among the Alps, during the day in summer, much ice is melted, and the water courses over the glaciers in brooks which, as they reach the crevasses, tumble down in rushing waterfalls, and are lost in the depths of the ice. Directed, however, by the form of the ice passage against the rocky floor of the valley, the water descends at a particular spot, carrying with it the sand, mud, and stones, which it may have swept away, from the surface of the glacier. By means of these materials it erodes deep potholes (moulines), in which the



THE GLACIAL POTHOLE IN THE NATIONAL MUSEUM.



rounded detritus is left as the crevasse is closed or moves up the valley."—Geikie, p. 400.

The pothole here exhibited is assumed to have been formed by a glacial ice stream in the manner described, during the melting of the ice sheet of the Glacial epoch. Similar holes are formed by running streams, but in this case there is now no stream in the near vicinity, nor traces of others than those temporarily formed by the melting ice. This hole was one of several situated on the rocky shore of a cove a few feet above tidewater action. The largest one is described as some 14 feet in depth. It is stated that a smaller hole is always to be found at a distance of a few feet to the southward of each of the large ones.

The inequalities of the interior of the hole are due to the unequal hardness of the material, and perhaps in part to the direction of the current of water. The rock is gneiss, and it will be observed that the hole is cut parallel with the foliation, the gneiss at this point standing nearly vertical.

Holes of this kind are variously called potholes, moulins, giants' kettles, and caldrons, and sometimes Indian ovens, or kettles, from the popular belief that they were excavated by the Indians and used in grinding corn or cooking food.

The following description regarding the work of extraction is taken from Dr. Farrington's notes:

"This pot-hole was one of a score or more found in the vicinity of Riggsville Landing, Georgetown, Maine. They are variously situated, in different degrees of preservation, and vary in depth from a few inches to fourteen feet. Nearly all were visited with a view to ascertaining which were best adapted for removal, but only one was found which seemed to be at all favorably situated for the purpose. This had a depth of 40 inches, a diameter of 20 inches, and was situated on the edge of a sea-wall which furnished one face of the block which it would be necessary to cut out, and giving room for horizontal drilling without the excavation of a large amount of rock from the front. The bed-rock here also appeared on careful examination to be nearly free from seams or joints, and though a gneiss of contorted structure, quite tough and homogeneous.

"To 'dig up a well,' however, is proverbially an impossible task, and even with so many favoring circumstances the work presented difficulties which made success seem very doubtful.

"So evident were these, especially when the small amount of money available for the work was taken into consideration, that it was some time before a contractor could be found willing to undertake it.

“ Finally, however, a Bath firm, Messrs. Liberty and Lake, consented to make the attempt, on condition of being freed from responsibility if the work was a failure.

“ The task in hand was to drill a solid row of vertical holes four feet deep around three sides of the pothole, then having excavated on the sea-wall side sufficiently to give room for the use of tools, to drill a horizontal row meeting these some inches below the bottom of the pothole and thus cut out a block containing it.

“ The first plan was to do the drilling by hand, but as seventy-five holes must be made, each four feet in depth, it was found that this would require the labor of as many men as could be employed for several months and an expense quite beyond the means available. Accordingly a steam drill and scow were procured and work begun with these on April 12. Some large masses of overhanging rock were soon found to interfere with the working of the drill, and as the removal of these by hand would have been very tedious and expensive, it was though best to employ powder. The result, however, was disastrous to the perfection of the pothole, since the concussion from the explosion shattered the ledge and opened several seams, showing that the rock was by no means the tough, homogeneous mass which it had appeared to be.

“ As the work proceeded this weakness became more apparent, as even the jar from the pounding of the drill caused pieces of the interior of the “ well ” to loosen and fall away and the seams to open still wider. All devices resorted to for overcoming this, such as keeping the stone wet and lining the interior with plaster and cement, were of little avail. Before the drilling could be completed other masses of rock had to be removed, and as our financial resources would not allow doing this by hand, powder was necessarily employed, to the further injury of the pothole as a specimen. After two weeks of this work the drilling was finished and the cutting by hand of the cores between the drill-holes commenced, a task which occupied about a week. To free the block from its bed, pairs of long, iron wedges were inserted in the horizontal holes at the bottom and driven in till the mass was raised a few inches, when it was brought forward and grappled with a chain. It was then hoisted by means of a derrick, transferred to a scow (great care being necessary in this operation lest the block should break apart), and, on May 2d, towed to Bath, where it remained for some days before being shipped to Washington.

“ For the guidance of those who would undertake similar work it should be noted that sufficient means ought to be provided to per-



form the task without the use of explosives, since these are certain to shatter the rock to a greater or less extent. The damage might be less to a rock of different structure, such as granite, but in the present instance the disintegrating action of ice and water upon the interior of the pothole for ages has necessarily left it in a brittle condition.

“Acknowledgments are due Mr. G. C. Campbell, owner of the land on which the pothole was situated, for the gift of the stone and for assistance rendered in every way possible to facilitate the work. To Messrs. Liberty and Lake credit is given for their enterprise in undertaking the work and for the ingenuity and skill displayed in overcoming its difficulties.”

## NOTES ON THE HERONS OF THE DISTRICT OF COLUMBIA

By PAUL BARTSCH

The extensive tidewater marshes bordering the two arms of the Potomac at Washington afford splendid feeding grounds for many of our birds, particularly the water birds and waders, and are doubtless responsible for the large number of the latter which visit the District of Columbia each season. Birds as large and beautiful as our herons are always conspicuous marks and must of necessity be shy to keep from serving as targets for the ever-present gunner. It is this habit, I am sure, which has led many persons to deem it necessary to visit secluded swamps, or even the subtropical everglades of Florida, to see herons in their native haunts, whereas a little search might reveal these wary members in their own locality where they may even rear their young.

No fewer than nine of the eighteen species which inhabit North America have been recorded within the limited area of the District of Columbia; four have been found breeding, and the Great Blue Heron, which is with us in small numbers all the year, is strongly suspected of conducting his domestic affairs within our territory.

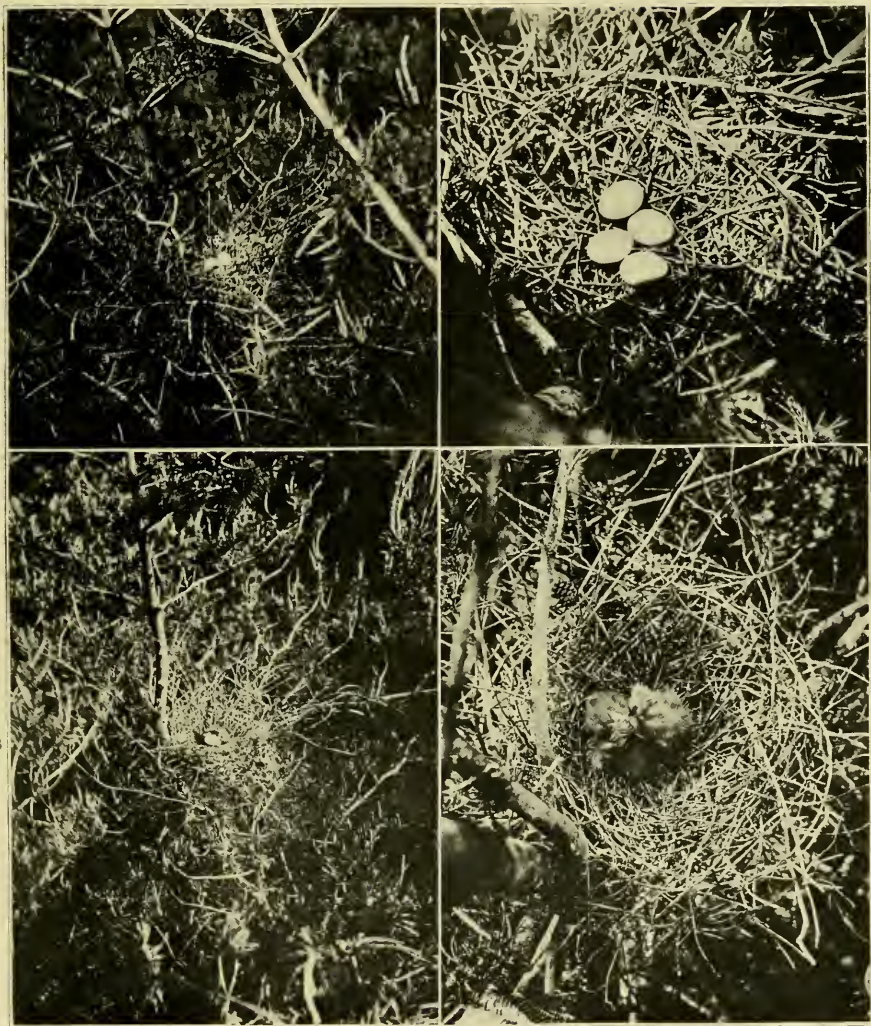
The most abundant member of the family is the Black-crowned Night Heron (*Nycticorax Nycticorax naevius*), or Quak, as he is usually called by the untutored (plate xxxv, 2). He is about 25 inches long, with bright-red eyes, black bill, and pale yellow legs and feet; the feathers of the crown are glossy greenish-black, except three long, narrow, white plumes which stream downward over the equally glossy greenish-black back; the forehead, neck, and median underparts are creamy-white, shading gradually to ashy on the sides, while the wings and tail are deep ash-gray.

Three colonies of these birds have their breeding grounds within the District and a fourth has been reported only a short distance beyond its limits. All of these are in small, dense pine coppices. In 1902 I visited two of these at various times while tenanted. In the latter part of April most of the nests, which were



1. Nesting site of Colony I of the Black-crowned Night Heron. 2. Adult flying (same colony).





1 Nest and eggs of Black-crowned Night Heron in situ. 2. Detailed view of same. 3. Young and eggs of same, just hatched and hatching. 4. The young three days after hatching.



placed in the tops of slender pines, close to the center, twenty-five to forty feet from the ground, contained eggs. The nests (plate XXXIII, 1) are poor structures, mere platforms of dead twigs, somewhat depressed in the center and abundantly chalked with the excreta of the birds; they are so thin that the eggs could frequently be seen through them from the ground.

Night Herons, as their name implies, are nocturnal in their habits. During the day all is quiet at the heronry. The males sit in the pines while the females pursue their task of incubation. Late in the afternoon, however, they leave the breeding grounds, flying in all directions to their favored hunting places. If disturbed during the day they will leave the trees with a few short, harsh quacks, sail about overhead for a while (plate XXXII, 2), then settle down quietly to watch the proceedings of the intruder. If the colony be invaded a little later when the large, light bluish-green eggs (plate XXXIII, 2) have delivered up their charge, the anxiety of the parents becomes more manifest and the birds leave the premises more reluctantly; in fact, it seems almost as if one had invaded a hen-roost, each bird shrieking and cackling as he or she leaves the nest or perch. Add to this the notes or calls of the young, and one has a fair notion of the din that greets him.

The young at birth (plate XXXIII, 3) are about as ugly birdlings as can be imagined; they are dark-skinned, wet, almost nude, with immense heads and large bills, quite out of proportion to the rest of the body, bearing a fairly strong, pointed knob at the tip which assisted them in breaking their egg-shell prisons. Weak and limp they lie stretched out in the middle of the nest. But a few hours bring wonderful changes. The wet down which clung closely to the body has become dried and fluffed up and the little birds are now enveloped in a coat of fine slaty-blue down. They even possess a decided head-crest of somewhat lighter color than the body-down, which gives to them a grotesque if not formidable appearance. Young herons grow very rapidly. Three days after hatching they are much increased in size, having considerably longer down and the first indications of pin-feathers (plate XXXIII, 4). By the end of the first week they are fairly bristling with pin-feathers and the feather-tracts have become strongly marked (plate XXXIV, 1). On the tenth day (plate XXXIV, 2) many of the feather-sheaths have become ruptured at the tips, and the birds begin to appear in their first plumage. About three weeks mark the termination of their stay in the nest

(plate xxxiv, 3) ; they are now almost as large as their parents, but quite differently colored, bearing still the little ivory tip at the point of the bill. Leaving the nest, they climb into the branches, a very praiseworthy act, for the old home and immediate surroundings have been thoroughly fouled by the combined wastes of the whole family, the nest, its supporting branches, and everything below it being completely whitewashed with the excreta of the birds, while undigested or dropped food adds to the disagreeableness of their old quarters. Then, too, from the branches they are better able to see the parents as they return from their foraging expeditions.

Young herons, though weak, have several methods of defense. When one climbs a tree in which the young have passed the second week, and the movements of the climbing begin to shake it, he may be sure to receive a contribution of whitewash from the various members. If the climber persists, the birds will even sacrifice their last meal in his favor, or rather disfavor, and a continuance of the climber's efforts will be met by the bird's final resort, which is to launch at the intruder with full force, spreading his wings and opening his cavernous mouth, striking with such violence that were he not securely anchored by his feet, he must surely be carried some distance beyond the nest. His fierce appearance and method of attack would repel any foe which might propose to dine upon his tender flesh.

By looking out over the tree-tops about the end of June, one may see many heron sentinels (plate xxxiv, 4) watching and waiting in the tips of trees. It is interesting to see how successfully these birds, built especially for the marsh, carry on arboreal life. The young, if disturbed when out in the branches, will, if old enough, either fly to a neighboring tree or climb rapidly from branch to branch. If they lose their balance in a jump, or fail to grasp a branch or twig with their toes, the bill comes to their aid ; and I have seen birds suspended by their bills for some minutes, struggling all the while to reach the same twig with their toes, usually with success. A bird may even strike a branch with its neck, in which case this member is instantly crooked and serves as a hook to hold him until he regains his balance.

The feeding is all done at night, and it is interesting to be in the colony after sunset—such clamoring, such calling, such din ! Everyone, no doubt, has heard the racket with which young crows greet their parents when they come with food. The heron's greeting is





1. Young Black-crowned Night Herons seven days old. 2. Same, ten days old. 3. Same, three weeks old. 4. A favorite position in the tree-top after leaving the nest.





1



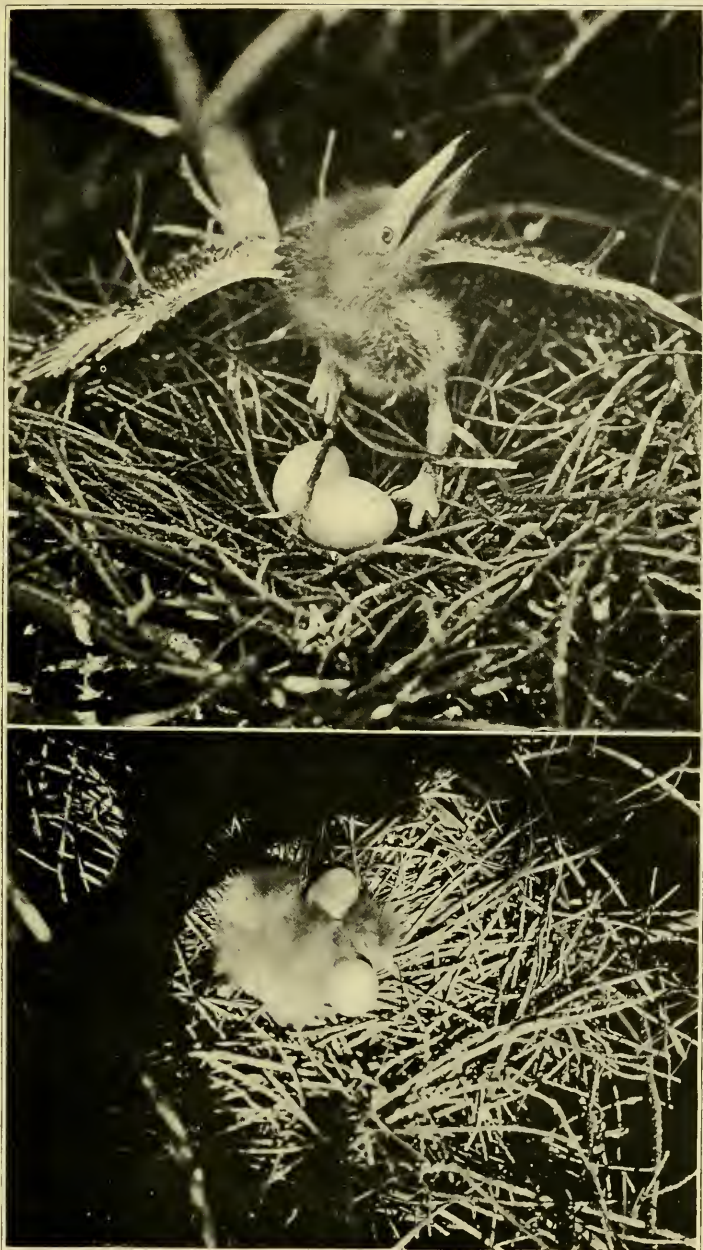
2

1 Young Black-crowned Night Heron in full juvenile dress. 2. An adult.









1. Two young Green Herons 24 hours old and two added eggs.  
2. Twelve days old—on the defense.







1, 3. The white phase of the Little Blue Heron. 2. Great Blue Heron in a tree. 4. Little Blue Herons feeding on Anacostia River. 5. Roosting place of American Egret and Little Blue Heron. 6. American Egret on the marsh.



When I visited the heron colony for the first time, it occurred to me that some light might be shed on one or more of these unsolved problems, at least so far as the present species is concerned, by marking the successive broods of young birds for a number of years. I explained the situation to Dr. F. W. True, Head Curator of Biology in the National Museum, who agreed to procure the necessary bands. These were inscribed "Return to Smithsonian Institution," and bore the year and a serial number. Unfortunately no aluminum tubing of the desired caliber could be obtained at once, hence the bands arrived so late in the season that only twenty-three herons of the entire heronry were marked.

These bands are mere rings, of extremely light weight, large enough to fit comfortably about the tarsus of the adult bird. The fact that the bands are closed necessitates very early application, since the foot soon grows too large to permit the ring to slip over it. Once on, there is little danger of its ever being dislodged, for the heron's toes are always partly spread as he clings to the twigs of his nest. Only one return resulted from the 1902 marking of Night Herons; this was a specimen shot September 24, 1902, at Abington, Maryland, about fifty-five miles northeast of Washington.

During the present year (1903) both colonies have changed quarters. One of the colonies selected an adjacent hillside where eighty-nine nests have been counted. The location of the other is still unknown, since lack of time prevented a thorough search for it. No complete systematic survey was made of the known colony, which was in a mixed forest. All but seven of the nests were placed in pines, the others in oaks. Four trees harbored two nests each.

Seventy-eight young birds were banded in 1903, five of which have already been heard from. The first was captured July 19 in a street in Leesburg, Virginia; the second was caught July 20 in a fish-trap on the Potomac below Washington; the third was shot at Pennsville, New Jersey, July 18; while the fourth and fifth were found dead under the tree in which the young had been marked. The birds were almost full grown, and there are strong indications that the last two specimens had been stoned to death by ruthless boys before they left their nesting tree.

I visited this colony on August 10, and was surprised to find about a dozen large young present with their parents. These must have been a second brood, raised, perhaps, by the birds whose first nest had been plundered by some small boys after incubation was well advanced. In the preceding year (1902) a large number of the eggs were carried off from the smaller of the two colonies and the

steps taken by many of those who were in a position to render aid should have prevented a similar occurrence.

The nearest relative of the Black-crowned Night Heron is the Yellow-crowned Night Heron (*Nyctinassa violacea*). Of the occurrence of this species in the District of Columbia there is but a single record—that of a juvenile individual, captured in the Smithsonian grounds, the skin of which is in the National Museum collection.

The remaining seven species listed for the District are diurnal waders and may be found feeding on the marshes and along creeks and lakes during the day. The most abundant of these is the little Green Heron (*Butorides virescens*), a bird of many names, among the most common of which are Shitepoke and Fly-up-the-creek. He is not a sociable fellow, shunning company and rarely allowing other birds to feed or to build their homes near him. For a nesting site he chooses, like the Night Heron, a pine coppice and builds an equally flimsy nest on which the four pale-blue eggs are deposited. The young are even more downy than those of the Night Heron, and are altogether much more dainty and fluffy than the latter. Their color, too, is much softer, somewhat lighter and more bluish—almost maltese. Plate XXXVI, 1, 2, shows the changes which took place in the same bird in twelve days.

It is interesting to watch this bird on his hunting ground as he moves stealthily along the shore, with indrawn neck, horizontally tilted body, and forward-pointed beak. If he espies a small fish or other object which may serve as food, he moves almost imperceptibly toward it, crouching lower and lower as he nears the victim, striking finally with such force that he appears fairly to lose his balance. This heron is not fond of wading, preferring to hunt along the shore or to seek his food by walking over the masses of aquatic vegetation which cover the Potomac to a great extent in summer and autumn.

The third species found breeding in the District of Columbia is the Least Bittern (*Ardetta exilis*). This is the smallest of our herons, and although with us every year from May to September, is seldom seen. His diminutive size and subdued coloration make him difficult to find, even in his favored haunts. One or two pairs breed annually in the cattail border which surrounds one of the fish-ponds near the Washington Monument. His large relative, the American Bittern (*Botaurus lentiginosus*), occasionally spends the winter in the District, but is most abundant in the fall, when he is frequently flushed by the ortolan hunter and added to his bag of game.

Anacostia River between Anacostia and Bennings in the latter part of August fairly teems with bird life. Countless numbers of





SNOWY HERON (photographed at National Zoological Park).

swallows find an abundant food supply on the marsh and an open field to train their wings for the long journey soon to be undertaken. This arm of the Potomac is at this season almost completely covered by wild rice and aquatic vegetation. The first covers completely the low mud flats and furnishes the thousands of sparrows, reed-birds, redwings, and ortolans with grain, while the latter forms a dense mat over all the water except the very narrow portion marking the channel. This green water-carpet is a favorite resort of the herons, and there may be seen the American Egret (*Herodias egretta*), that large white heron second in size only to the Great Blue (*Ardea herodias*) which is also present; the Little Blue (*Florida carulca*), and an occasional Snowy Heron (*Egretta candidissima*), all busily engaged in finding their daily food.

The most abundant of these is the Little Blue (plate xxxvii, 1, 3, 4), although few would recognize him as such, for at the season referred to there may be at least fifty white birds (a color phase of this species) to one of dark color. Their food consists almost exclusively of crayfish, which at this season have the habit of flipping from the bottom of the shallow water to the surface of the floating vegetation where they lie quiet for some time and fall an easy prey to the hungry heron. The Little Blue, like the Green Heron, seems to prefer walking to wading, though he is much more active than the latter species, flying up and down the marsh from one favorable feeding place to another. They are sociable birds, always fond of company.

The American Egret (plate xxxvii, 6) and the Great Blue (plate xxxvii, 2) occur in about equal numbers. The former has been known to nest at Arlington Cemetery. Both are fishers, fond of wading, the Great Blue even more so than the Egret. The latter frequently joins the Little Blues, when he appears as a giant of the same race. Among the host of white Little Blues there appears occasionally a bird, much more trim and graceful, whose yellow feet distinguish him at a glance from the other species. This is the Snowy Heron (*Egretta candidissima*), shown in plate xxxviii, which is undoubtedly the most beautiful of all our waders, although it is quite rare in the District of Columbia.

As evening advances, the few Night Herons which remain go to the Anacostia marsh, while the diurnal members rise one after another and fly up the stream. I followed them one evening and found a secluded place on the bank where the tops of several dead trees were fairly well surrounded and hidden by green vegetation. Here the herons had assembled in numbers and were preening their beautiful dresses, preparing for the night which was fast approaching (plate xxxvii, 5).

# PRELIMINARY REPORT ON AN ARCHEOLOGICAL TRIP TO THE WEST INDIES

BY J. WALTER FEWKES

## INTRODUCTION

The archeological results of a brief visit to Porto Rico in the spring of 1902 were so promising that the author was encouraged to renew his explorations in the following winter, when he could devote more time to his researches. Therefore in November he returned to the island where he continued until the close of May, 1903, with the exception of a month spent in Santo Domingo. The size of the collection of prehistoric objects made on this visit so far exceeded expectations that a mere preliminary report can call attention only to the more important results. These will be considered under two general heads—Excavations, and Description of Specimens. Excavations were confined to Porto Rico and were made in caves, village sites, and dance enclosures. The objects considered under “description of specimens” embrace those which were purchased and brought back to Washington, as well as others that could not be obtained.

## EXCAVATIONS

The nearest approach to ruins of prehistoric Porto Rican structures, now surviving, are enclosures surrounded by aligned stones, set on edge, which occur in the less frequented parts of the island. These enclosures are square or rectangular and their floor level is slightly below the surrounding surface. The stones forming their boundary walls are roughly hewn and sometimes bear pictographs, in one or two cases the upper end being rudely fashioned to represent the head or body of an idol. These structures, which are undoubtedly prehistoric, are sometimes called *cercados de los Indios*, or “Indian enclosures.” They are also locally known as *juegos de bola*, from the belief that they were used in a game of ball, called *batey*, of which the Indians were fond. Oviedo describes this ball game, saying that it was played in enclosures outside the pueblos, where there were seats for the cacique and the spectators. Following analogy, we may suppose that other gatherings took place in these enclosures, since they were situated near the villages.



We know, for instance, that the islanders had elaborate mortuary dances, called *areitos*, which occurred at the burial of a chief or cacique, and from knowledge of kindred people it is probable that these *areitos* were performed near the graves of the dead. Historians are silent regarding the position of the Antillean cemeteries or the situation of the plazas in which the *areitos* were performed, but a suspicion that the latter occurred in the *juegos de bola*, the only known prehistoric structures remaining in Porto Rico, suggested to the author that cemeteries should be sought in their vicinity. With this thought in mind he chose for investigation a *juego de bola* near Utuado, where there are many of these structures in a fairly good state of preservation.

The enclosure chosen for excavation lies about three miles from Utuado, on the left side of the road to Adjuntas. Several mounds are situated on the south side of this enclosure, one of which is partly cut through by the neighboring road. A few feet below the surface, in this exposure, the author found fragments of prehistoric pottery and a few human bones, a discovery which led him to dig a trench completely through the mound. In the course of this work, which occupied several workmen the greater part of a week, ten skeletons were exhumed within a limited area, and several skulls, two of which were comparatively well preserved, were found. While the majority of these human remains were so decayed that they crumbled before they could be taken from the moist soil, it was evident that they represented Indian interments. The skulls showed the artificial flattening characteristic of the Antilleans, and the position of the larger bones indicated that some of the bodies had been buried in a sitting posture. Prehistoric implements and a mortuary food bowl were found near one of the skeletons. These and other evidences led to the conviction that the mound excavated was an Indian cemetery, the first of its kind ever found in Porto Rico.

The position of this cemetery has an important bearing on the interpretation of the neighboring enclosure, for if the *areitos*, or mortuary dances, were held at the burial mounds, they must have taken place in the *juegos de bola* near the cemetery. Consequently these enclosures were not only places for the game of *batey*, as popular legends assert, but also for the performance of mortuary dances, during which songs were sung extolling the illustrious deeds of the dead in peace and war and their magic power in aid of the living.

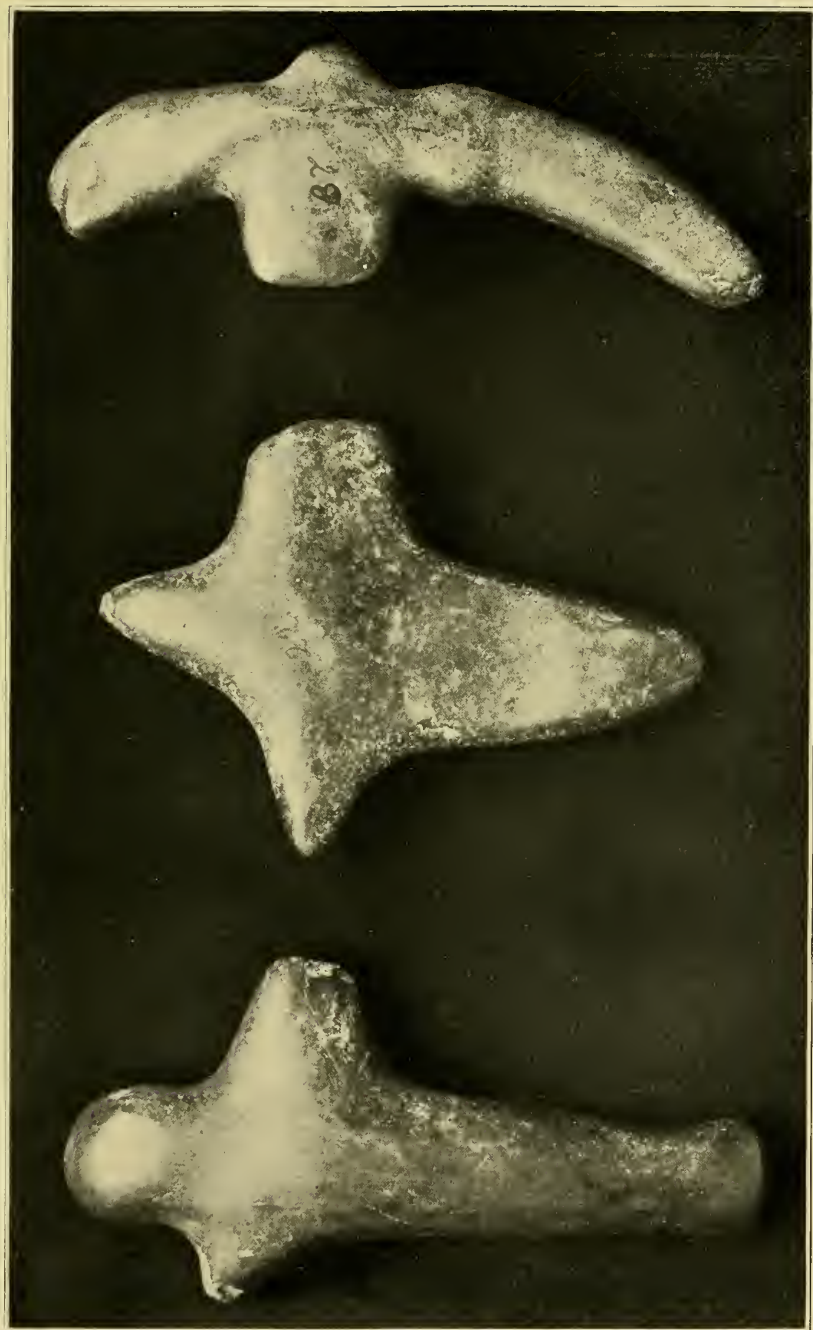
## CAVE EXPLORATION

Porto Rico has many noticeable caves, some of which were utilized by the aborigines of the island. While there is no good evidence that these caverns were dwellings of the Indians for any considerable time, there is abundant proof that they were resorted to in prehistoric times for several purposes. They undoubtedly served, especially after the advent of the Europeans, as places of refuge and perhaps for temporary shelter or for the performance of secret rites when the aboriginal cultus was prohibited in public. There are many evidences that the caves were used for burial, which implies that they were places of ceremony, especially as ancestor worship was the main element in the Antillean religion. The walls of many of these caverns bear religious symbols, and niches where idols of stone or wood once stood can still be seen. These caverns are reputed to have yielded many prehistoric objects, and it is probable that others could yet be found in their floors. The author was anxious to test this belief by systematic excavation, so after visiting many of the most notable caves he finally chose for extended study one, most conveniently situated for that purpose, on the coast, three miles north of Manati, called Cueva de las Golondrinas, "Cave of the Swallows."

Excavations in this cave showed that it was once frequented by the aborigines, while pictographs on the walls gave other evidence of their former presence. There were found among the débris, on the floor, many fragments of the pottery peculiar to the islanders, and other evidences of primitive life, among which were broken celts, bones of animals which had served for food, and also ashes and charcoal. All of the implements and utensils were of ancient manufacture and so numerous that many people must have frequented this coast region and used this cave as their camping place. A few broken human bones were also uncovered, but whether they indicated former anthropophagous feasts or hurried interments could not be determined. The trenches dug in the cave floor through ten feet of débris showed, at all levels, art objects similar to those occurring on the surface, indicating no change in culture. There was no evidence of any great modification between the life of the earlier and the later occupants, and no satisfactory proof that the occupancy of the cave was of very great antiquity.

## DESCRIPTION OF SPECIMENS

In the following pages the author will comment in a general way on the unique as well as on some of the more striking and unusual



CELTS WITH STONE HANDLES FROM SANTO DOMINGO.  
1. Length,  $9\frac{1}{4}$  inches. 2. Length,  $7\frac{1}{4}$  inches. 3. Length, 9 inches.



specimens which he saw or obtained on the trip. It will not be possible at this time to compare these with similar objects already known; a detailed description is reserved for a more extended report, when available documentary and historical references to the uses of many of the objects will be freely quoted. Only such specimens are here considered as will indicate the wealth of new material possible to obtain in this almost neglected field. The size and value of the collection acquired during a comparatively brief sojourn is the best possible evidence of the promise which the West Indian field affords to the archeologist.

The collection brought back to Washington, including the specimens obtained by excavation and by purchase, numbers over twelve hundred specimens. These objects vary in scientific value, for while many are duplicates of forms already known to students, others are entirely unique. The most important collection obtained by purchase was from the Right Reverend Fernandez Meriño, formerly President, now Archbishop of Santo Domingo. This famous collection, which was the best on the island, contains about one hundred and ten specimens, most of which are unique. Considering our lack of knowledge of the antiquities of Santo Domingo, and the scarcity of specimens from this island in the National Museum, the acquisition of this rare collection, gathered with care during many years by a learned man, is gratifying.

Collections were also purchased in Porto Rico. Among these may be mentioned that of Sr. Zeno Gandia, formerly owned by the Gabinete de Lectura, a scientific and literary society which formerly existed in Ponce. A small collection was also acquired from Señor Angelis of Catania, and another from Señor Fernandez of Loquillo, in the eastern end of the island.

But by far the largest number of specimens from Porto Rico was obtained, one or two at a time, from the natives, commonly called *Jibaros*. For this purpose the author went from house to house in the poorer sections of several towns, as Manati, Ciales, Toa Alta, Toa Baja, Vega Alta, and Dorado, soliciting these objects directly from the people. Almost every small cabin was found to possess one or more perfect celts, called *pedras de rayo*, or thunder-stones, concerning which the owners possessed considerable folklore.

But the material obtained by purchase forms only a part of that made use of by the author in his studies. He availed himself of the opportunities afforded by his trip to study local collections which could not be acquired. Among these may be mentioned a Dominican collection owned by Señor Imbert, of Puerto Plata, who, al-

though unwilling to sell, gave every facility for study, kindly allowing the author free use of his notes and catalogue, in which are recorded the localities from which the specimens were obtained. The Imbert collection contains several unique objects, among which are a wooden idol (the best yet discovered in the West Indies), five sticks once used to induce vomiting, several pieces of prehistoric pottery of unusual shape, and numerous stone implements and rare fetishes. Another Dominican collection, owned by Señor Desangles (a native painter whose picture of Conoabo attracted attention at the Pan American Exposition in Buffalo), contains, among other prehistoric objects, a human effigy made of burnt clay and probably unique. Sr. José Gabriel Garcia, an author and a member of the leading publishing firm in Santo Domingo city, has many Indian specimens. The late Dr. Alesandro Llenas, of Santiago de los Caballeros, owned a well-preserved aboriginal wooden stool and two prehistoric Antillean skulls; and a Mr. Hall, an American of Puerto Plata, has a collection of stone objects. Both of the latter collections were generously placed at the disposal of the writer for study.

There still remain in Porto Rico many scattered prehistoric objects and one or two collections, among which may be mentioned that of Padre Nazario of Guayanilla. The owner kindly allowed the author to inspect this important collection, which contains many rare and unique objects.

#### STONE IMPLEMENTS

*Celts.*—The so-called celts which, as a rule, are finely polished, pointed at one end, and sharpened at the other, are called by the country people, as above stated, *pedras de rayo*, or “thunder-stones,” since they are believed to have fallen from the sky. Almost every household has one or more of these stones, which are thought to afford protection from lightning, or to be efficacious in the treatment of certain bodily disorders. The method employed by the natives to determine whether a stone is a “thunder-stone” or not, is to tie a string about it and put it in the flame of a candle. If the string burns immediately, the stone is not regarded as a true thunder-stone. About five hundred celts tested in this way and regarded by their owners as veritable thunder-stones were purchased. These celts are of many forms, from simple polished stones to well-made hatchets. Only one specimen of all those obtained in Porto Rico was provided with a groove for the attachment of a handle; in this specimen the groove was roughly pecked and was not polished like the remaining surface.



STONE IMPLEMENTS FROM SANTO DOMINGO AND PORTO RICO.

1. Polishing Implement (length,  $8\frac{1}{4}$  inches). 2. Polishing Implement (length,  $4\frac{1}{2}$  inches). 3. Ceremonial Celt (length,  $9\frac{1}{2}$  inches). 4. Ceremonial Baton (length, 14 inches).





One of the implements collected resembles a double-edged axe; it is oval in form when seen in profile, has a rough surface, and is without a notch or groove for hafting. Several specimens show marks of surface pecking, but not of chipping, their present finish evidently having been produced by rubbing or polishing.

There are several flat, rough, double-edged stone implements, each with a notch cut on the opposite sides, evidently for the secure attachment of a handle. This variety of celt is well represented in the collections from Santo Domingo, but it has not yet been found in Porto Rico. None of these is smoothly polished and not one is petaloid in form. Other celts have a rough surface, and are pointed at one end and broad at the other, with a ridge marking the place of hafting. This type, which occurs more abundantly in Santo Domingo than in Porto Rico, recalls Carib implements described as having been found in the Lesser Antilles.

Several implements of soft stone are pointed at one pole and flattened to a cutting edge at the other. They have plane faces and rounded edges, thus differing from the next group, in which the faces are convex. There are no grooves or ridges for hafting.

The majority of celts are called petaloid from the resemblance of their profile to the petal of a flower. They are of all sizes and in some instances are made of stone either rare or unknown to the islands. The surface of these implements is convex and finely polished, and their forms show variation in the length as compared with the breadth. The cutting edge may be straight, slightly curved, or at an angle to the axis. In a few instances the "pointed" end is blunt, but in no case is there a groove or notch for the attachment of a handle. There is little doubt, however, that the celts were once provided with wooden handles, the stone having been inserted in a cleft in the wood and lashed with fiber or held with gum.

In the Archbishop's collection there are three celts with the blade and handle made of solid stone (plate xxxix). One of these (figure 2) is rudely fashioned, but another (figure 1) in point of finish ranks with the finest known examples.

Several writers on the archeology of the West Indies record the existence of celts with heads or bodies cut in low relief on the sides. A beautiful example of this work in the Archbishop's collection has a human head and a part of the body and arms cut on one face, as shown in plate xl, 3. This fine implement is termed a ceremonial celt on the theory that it was used in Antillean rites. It probably was not provided with a handle, which would have concealed portions of the figure in relief.

*Chisels and other Implements.*—A number of stone chisels, used for incising the complicated designs on objects of wood or stone were obtained in Porto Rico. These are cylindrical, and are either flattened to a sharp edge or pointed at one or both extremities. Some of these chisels have a cutting edge on one end and a point at the other, while others are blunt at one end with a point or an edge at the other. One of the chisels is perforated at the end opposite the sharp edge.

*Other Stone Objects.*—A stone implement, not belonging to the petaloid type of celts nor to the chisels, is of ovoid form which continues at one pole into a slightly curved extension that fits the hand so well as to suggest its use as a mawl.

Another type of stone objects, possibly ceremonial, consists of a stone disk with a slender handle attached to the rim. The richly decorated specimen of this type in the Smithsonian collection (plate XL, 4) was obtained in Santo Domingo by Mr. Gabb.

Two other stones (plate XL, 1, 2), one hard and black, the other brown and of softer material, are flat at one end, with bifurcated tips to the handles. One may assume that these objects were used as rubbing or polishing implements. Handles with bifurcated tips occur also in stone implements from the Lesser Antilles.

One of the stones in the Archbishop's collection has a profile like that of a clam-shell, the valve area having rounded projections. There is also in this collection a stone of melon shape, with meridian surface grooves which remind one of the ambulacral plates of a sea-urchin. The irregularity of these grooves and the artificially pecked surface stamp this object as an implement rather than as a fossil, which it somewhat resembles.

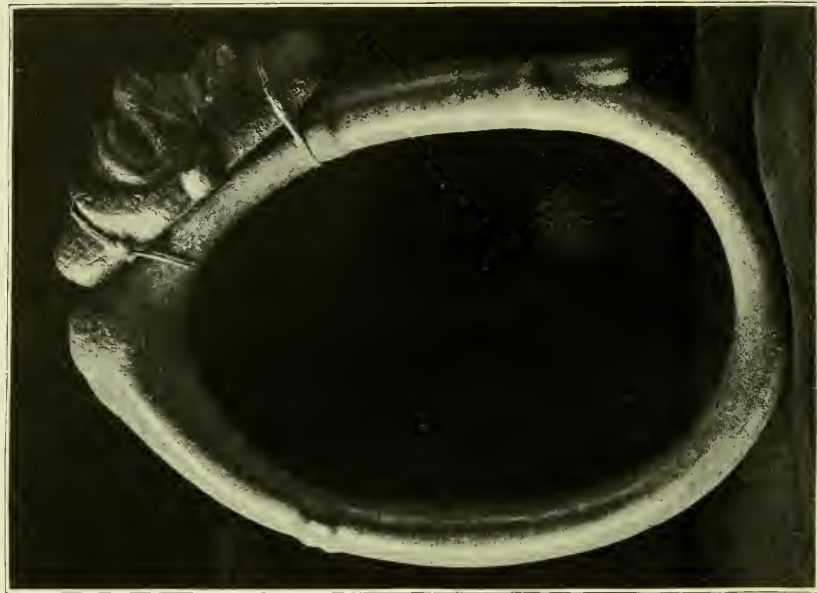
Some of the many stone balls found in Porto Rico, especially in ball courts or in streams, are undoubtedly artificial; but others are natural, water-worn boulders. They vary in size from several feet in diameter to that of a marble. One of the smaller specimens, made of soft stone, has small pits at the opposite poles.

Among the problematical objects from Porto Rico are two white stones unlike any yet described. They are cylindrical, four and a half inches long by an inch in diameter, and perforated at each end in such manner as to suggest, at first glance, that they were strung together in necklaces. A similar stone object, somewhat better made and ornamented with a human hand carved in relief on the surface, was seen in the Nazario collection. The stone cylinders are symbolic, not decorative, objects, and were carried in the hand for some unknown purpose. In his excavations at Utuado the author found a similar object made of bone.





1. Flat circular stone. (Diameter, 17 inches.)



2. Stone ring with attached stone head. (Greatest diameter, 16 $\frac{3}{8}$  inches.)

STONE OBJECTS FROM PORTO RICO AND SANTO DOMINGO.

Stone beads, of which there are many in the Imbert collection, in addition to the perforation through the axis, often have a smaller hole near the end, at right angles to this perforation, possibly for the insertion of feathers.

One of many problematical specimens in the Archbishop's collection is a large, flat, circular stone with a perforated extension on the rim (plate XLI, 1). The author has seen another specimen, rectangular in shape, with two extensions, one on each angle of the same side. The use of these stones is unknown. It has been suggested that they were used to aid parturition, but there is no evidence to support this theory. One surface of the circular stone is decorated with a shallow, meandering groove; the other is without ornamentation.

Señor Imbert's collection contains a stone slab, a foot square, which the owner regards as a gaming implement. On each face there are six small pits arranged in two rows, and Señor Imbert believes that a pebble or other small object was placed under one or another of these pits and covered by the stone. It is supposed that, in playing the game, the opponent guessed under which depression the pebble was concealed, possibly indicating his choice by pointing at the corresponding depression on the upper surface. The author, having no other interpretation of the use of this slab, which is undoubtedly artificially worked and prehistoric, mentions this explanation more as a plausible hypothesis than as an exact determination of its use.

*Stone Mortars.*—Excavated stones, ranging widely in form and identified as mortars, were collected both in Santo Domingo and in Porto Rico. One of the best specimens, in the form of a shallow bowl, forms a part of the Archbishop's collection. Others are elongated or boat-shaped, and some have ornamented elevations on the rim.

In the Archbishop's collection, also, there is a flat stone slab with a shallow depression on one side as if designed to serve likewise as a mortar; but as the depression is perforated, it could not well have been used as such. It may have formed part of a primitive mill and have been used with an oval stone, flat on one side and convex on the other. The latter object, which has a pit in the middle and shallow grooves irregularly arranged in a radial direction on the convex side, may have served as a nether stone to the perforated slab.

*Ornamented Stone Pestles.*—The skill of the Antilleans in stone working is nowhere better shown than in the carvings on the handles of their pestles. These carvings are so well executed that the pestles

are sometimes called idols, and it is indeed possible that some of them may have served as such. The majority, however, were household implements, and were designed purely for secular use, the figures cut on the handles being merely for decoration. So far as they have been studied, the carved pestles from Santo Domingo excel in finish those of the other West Indian islands, the Porto Rican examples being cruder and less carefully made. The Archbishop's collection contains several fine pestles with ornamented handles, many of which are adorned with human figures having heads, bodies, and limbs beautifully cut. One of the best of these figures (plate XLII, 1) represents a human being lying on its back, with legs drawn up and hands resting on the knees. In another fine specimen the handle terminates in a carved human figure with legs drawn to the body (plate XLII, 2). The opposite end of the handle of this specimen, where it joins the base, is surrounded by an incised broken line—an ornamental motive which constantly appears in Antillean pottery. The well-made pestle shown in plate XLII, 6, has the head and body well cut on the handle, the arms and legs appearing on the sides.

The base of these pestles is ordinarily lenticular, but in the example shown in plate XLII, 5, it is spherical; the whole handle is fashioned into a human figure, the head being well made, the legs sculptured in low relief but appressed to the body. There is a simple pestle in which the handle takes the form of a bird, the head and wings being well represented. Other collections from Santo Domingo contain pestles with bird-shaped handles, the ends of which are modified into rude heads.

#### IDOLS

In order to show the position of idolatry in the primitive worship of the West Indians, a few words on the general nature of Antillean religion may be opportune. According to early writers the inhabitants of Santo Domingo worshiped stone, wood, and clay idols, called *zemis*. It is learned from the writings of Padre Roman Pane, Peter Martyr, Benzoni, and others, that the sun, earth, and other nature powers were also called *zemis*; therefore it is evident that the term was applied not only to idols, but to the spirits which they represented; thus the sky-god was called a *zemi* and its wooden image bore the same name, in which case the term was made to designate both magic powers and their personations, a custom universally followed in American religions. The Antilleans, according to the above authorities, likewise called their ancients or ancestors *zemis*,



ORNAMENTAL STONE PESTLES FROM SANTO DOMINGO.

1. Height,  $5\frac{1}{2}$  inches. 2. Height, 9 inches. 3. Height,  $4\frac{1}{4}$  inches. 4. Height,  $4\frac{3}{4}$  inches. 5. Height,  $5\frac{3}{4}$  inches. 6. Height,  $7\frac{1}{8}$  inches. 7. Height,  $7\frac{1}{8}$  inches.





and sometimes gave the same name to their priests. Relics of the dead, as human skulls or other bones, images or idols, and other symbols or paintings of the same, were known as *zemis*. Each clan had, in the keeping of a chief, an idol or image of an ancestral *semi*, the symbolism of which was characteristic of that clan. One Spanish writer declares that *zemis* are practically what Christians call angels—the immortal spirits of men. Here, also, the word refers to both the spirit and the personation—the magic power of the dead or an idol symbolizing or representing the same.

The worship of *zemis*, which practically included all supernaturals, gave rise to the use of a complicated system of objective symbols, idols, images, relics, and the like, each of which had a special and individual meaning. The idols were many and varied; they were made of wood, clay, or stone, and sometimes took the form of effigies of which the skulls or other bones of ancestors formed a part. There are representations of these various idols in several collections, but the present article will consider only those of stone, wood, and clay.

*Stone Rings.*—Among the problematic archeological objects from the West Indies none is more characteristic of Porto Rico than the so-called stone collars or rings. They are practically limited to Porto Rico and the immediately adjacent islands, and to the eastern end of Santo Domingo, for they have not been reported from Cuba, Jamaica, or the continent. There are approximately one hundred of these objects in the museums of Europe and the United States, and a few still remain in Porto Rico. To the Latimer collection, which in these objects is the richest in the world, the author has added eight specimens, some of which are unusually fine.

The use and meaning of the stone rings have given rise to much speculation, since historical records give no satisfactory clue to their function. These objects were apparently not mentioned by any chronicler contemporary with their use, and, indeed, they escaped notice until a little more than fifty years ago—three and a half centuries after the Indians had disappeared.

It has been conjectured that they were bandoliers worn by the caciques as insignia of rank, but some of them are too small for such purpose and others too heavy for a man to bear on his shoulders. The author believes that they were idols, and has therefore included them among the *zemis*. As an interpretation of what the objects represent, it is suggested that they are images of the coiled bodies of serpents or reptilian monsters which personated some great nature power, possibly a sky or wind god.

The heads of these idols, however, are not apparent, although no idol can be regarded as complete without the head. For this important part, which in all idols among primitive men is most carefully made, we look to another group of polished stone objects, also peculiar to the islands in which the stone rings are found, viz., the masks and heads, called mammiform images, which have been figured by several writers on West Indian antiquities. These masks are supposed to have formerly fitted certain roughened surfaces on the stone rings forming the coiled bodies of the serpent, in the manner indicated in plate XLI, 2. The arguments for and against this hypothesis, which was first suggested by Sr. J. J. Acosta in the notes to his edition of Inigo's *Historia de Puerto Rico*, cannot be given here, but will be considered more at length in other publications.

*Idols with Conical Projections.*—Among the stone objects in the Latimer collection, described by Prof. O. T. Mason,<sup>1</sup> occur certain tripointed specimens to which he gives the name "mammiform stones." These specimens, like the stone collars, have remained enigmatical up to the present time, but the true use of some of them, in the opinion of the writer, was, as above suggested, for attachment as heads to the coiled serpents or reptiles of which the stone rings represent the bodies.

Several of the tripointed stones bear representations of fore or hind legs (plate XLIII, 6) on a projection opposite that which contains the head. The fore-legs, when present, are cut on the sides of the conic elevation, while in the region of the shoulders are pits, which indeed are sometimes present even when there is no representation of limbs. In one or two instances there are two of these pits on each side. Some doubt arises whether these pits represent ears or shoulders, but their position on the legs corresponds with similar depressions sometimes found on the front legs of stools made in animal form. Possibly stone or shell ornaments were once inserted in these pits, in which case they doubtless represented ear pendants.

The fact that several of these tripointed stones have fore or hind legs cut upon them shows conclusively that in some instances they represent the complete bodies of idols, and were not fastened as heads to stone rings or other objects. An examination of the form of the head, and especially of the mouth, of these stones, reveals a similarity to corresponding parts of different animals, as fishes, lizards, and birds.

In considering the outlines of these tripointed stones it is found

<sup>1</sup> Latimer and Guesde Porto Rico Collections, *Smithsonian Reports*, 1876 and 1884, reprinted 1899.





IDOLS WITH CONICAL PROJECTIONS FROM SANTO DOMINGO AND PORTO RICO.

- 1. Third type. 2. Third type (side view). 3. Trilobate stone (length, 5½ inches).
- 4. First type (length, 9½ inches).
- 5. First type (length, 8½ inches).
- 6. Second type (length, 7⅔ inches).

1

6

1 2

4 5

that, while preserving much the same form, they fall into several types. In the first type (plates XLIII, 4, 5) one of the prominences is cut in the form of a head, while another represents the limbs or body, the conical prominence remaining unchanged. In another type (plate XLIII, 6) all three prominences are without carving, but a face is cut between two of their projections, the legs either appearing on the side of the stone or being wholly unrepresented. In still another type (plate XLIII, 1, 2) the conical prominence is modified into a mouth or nose, giving the stone, in some instances, the form of a mask.

The Archbishop's collection contains a good specimen (plate XLIII, 5) of the first type of these objects; there is a head on one projection, limbs on the other, and a conical protuberance between the two. Two specimens of this type from Porto Rico differ but little from those in the Latimer collection. One of the latter (plate XLIII, 4) is of fine brown stone, the other (plate XLIV, 2) of black basaltic rock. Both are smooth and well made, while the latter is one of the largest yet recorded. Another (plate XLIV, 1) of the same type, made of white marble with yellow patches, may be considered the finest specimen in the collection obtained by the writer. Its conical process, instead of being pointed, is hemispherical, and the surface is decorated with incised geometric figures, among which the circle and triangle predominate. A small mammiform idol, also of the second type, is made of black stone with surface decorated with incised circles and other geometrical figures. This object shows superficial remnants of a black resin or varnish which possibly originally covered the surface of all these idols. A pit on the back of the conoidal projection recalls a similar depression on the head of certain other specimens. Not all these stones of the second type have faces cut upon the conical protuberances; several were found which are perfectly smooth, although their forms are strictly the same as those on which eyes, nose, and mouth are indicated. One of these, which is very small and smoothly polished, is significant owing to the light which it sheds on the use of these stones. This I will shortly refer to.

The third type (plate XLIII, 1, 2) includes specimens in which the conical projection does not exist or in which its place is taken by the snout or mouth of an animal. The general form of this type is the same as that of the other mammiform images, having the slightly concave, rough under surface terminating in a prominence at each end, while the conical projection is replaced by a mouth or nose, recalling a form resembling a mask. In other words we have in

these objects an intermediate morphological link between mammiform stones and masks, although more closely allied to the former.

Two specimens of this hitherto unknown type of idols occur in the Archbishop's collection. The first (plate XLIV, 3), made of light brown stone, has a shallow eye, an elongated mouth, and fore-legs cut on the sides in low relief. The second example (plate XLIV, 4) is even more elaborately made, the details of the jaw being more completely worked out. In this specimen the fore-legs are not represented, but the raised forehead and throat ridges peculiar to other mammiform images are well shown. The eye sockets are deep, the nostrils appear in relief, and there are superficial markings suggesting teeth.

In studying the form and position of parts of this type it is evident that it is practically the same as that to which belong the preceding two with conical projections on top of the head, so that any valid objection to a theory of the use of the objects belonging to this type applies also to the others.

The specimen next to be considered (plate XLIII, 1, 2) also has the tripointed form of the mammiform zemi, but it lacks the conoidal elevation, and in that respect is more like a mask. It resembles the third type, or the two specimens last mentioned, except that the mouth, instead of replacing the conical elevation, is situated on one side, the nose being extraordinarily flattened. This specimen, like the last two, came from Santo Domingo; it was purchased from Sr. Zeno Gandia and formerly belonged to the Gabinete de Lectura at Ponce, Porto Rico.

The author also purchased in Porto Rico a rude stone head, resembling in certain respects the one last mentioned, but differing from it in having a projection at the top. A corresponding protuberance forms the neck, suggesting that the stone may have been lashed to some other object, such as a stone ring. A beautiful stone of the third type, in which the nose takes the place of the conoid projection, was purchased from Señor Gandia. Its lower, slightly concave surface has been fitted to one of the Porto Rican collars, as shown in plate XLI, 2.

In the absence of information regarding the use of these tripointed or mammiform stones here identified as idols, it has been suggested that they were merely highly ornamented mortars, the object when in use being reversed—the conoidal projection being inserted in the ground for stability, and the slightly concave surface thus brought uppermost. This theory is advocated by Im Thurn, a generally excellent authority on account of his intimate knowledge of related tribes.





STONE IDOLS FROM SANTO DOMINGO AND PORTO RICO. 1. First type (length,  $8\frac{1}{4}$  inches). 2. First type (length,  $10\frac{3}{4}$  inches). 3. Third type (length,  $11\frac{1}{2}$  inches). 4. Third type (length, 9 inches).



But if this supposition be correct, why, it may be asked, has so much care been given to the ornamentation of the conoid prominence in the third type, which would be buried in the earth? It may also be pertinent to call attention to the tripointed stones with perfectly smooth surfaces, and particularly to one which is barely half an inch in length. Certainly these are not adapted in size for grinding implements, and their superficial polish would also seem to prohibit their use as such. It is evident that at least the small and smooth tripointed stones were not used as mortars, and as their form is practically the same as that of the larger ones, although the latter have a rough surface, it is doubtful if either type was used for grinding.

A direct statement by Ramon Pane regarding different forms of *zemis* should have great weight in determining the significance of these stones. He says that the Haytians had a form of *zemi* with "three points," evidently referring to some of the tripointed stones above mentioned. This writer also states that this form of tripointed objects was believed to make the *guica* grow.

*Stone Disks with Faces on one Side.*—Two specimens of stone disks, bearing faces, are contained in the collection from Porto Rico. Although in their general outline they resemble the so-called masks of other authors, they differ from them in some particulars. It is possible to interpret them as symbolic masks, but while they could not have been worn over the face, they may have been attached to staves and set in mortuary mounds or carried in processions during the rites attending ancestor worship.

A rough stone, convex on one side and flat on the other, on which is a well-cut face, was purchased from Sr. Zeno Gandia, and a somewhat similar stone, a part of the edge of which is broken, was collected by the author in the mountains near Utuado, Porto Rico.

A small head with a part of the body occurs in the Imbert collection at Puerto Plata; it is of finely polished syenitic rock, and the eyes, nose, ears, mouth, and teeth are unusually well made. This object was evidently an idol.

The Archbishop's collection contains a stone (plate XLIII, 3) which, when viewed in profile, is seen to be trilobate, having a median projection flanked on each side by smaller ones. The middle projection has three depressions so arranged as to suggest eyes and mouth. This object is provisionally regarded as a crude idol of the mammiform variety, but it bears no resemblance to the tripointed forms.

Another stone head in the Imbert collection is spherical in form and has an extension at each pole in which there is a slight depression. The eyes, nose, and mouth are represented in relief; but the

remarkable feature of this specimen is three "wens" or knobs, one on the forehead and one on each temple. This head was found in the ruins of old Fort Santo Tomas, Santo Domingo, and was presented to Señor Imbert by José Roman Perez.

In a collection of prehistoric objects once the property of the late Dr. Llenas, of Santiago de los Caballeros, but now owned by his son, there is a similar specimen which should be mentioned in connection with the one last described. This is a stone ball like those so constantly found near the *juegos de bola* of Porto Rico, having the surface smooth with the exception of three knobs arranged in a triangle at one pole. Unlike the Imbert specimen, however, no face is carved upon it.

#### STONE AMULETS

A considerable number of small stone fetishes or amulets were seen in various localities of Santo Domingo and Porto Rico and a few were purchased by the author for the National Museum. Among the stone fetishes in Santo Domingo may be mentioned those in the collection of Señor Imbert of Puerto Plata, and those in the Nazario collection of Porto Rico. The specimens obtained convey a fair idea of the typical form of these objects.

The Antillean stone amulets are regarded as personal fetishes which were worn on the neck or breast. Early writers speak of the native custom of wearing small stone clan fetishes also on their foreheads when the warriors went into battle.

In the Archbishop's collection there is a twin amulet or fetish (plate XLVII, 4) representing two individuals united at their edges, the only specimen of its form known to the writer. One of the amulets of this general type, which is made of white stone, is perforated from one side to the other, but most of them have holes at the edges and not through the body.

The finest amulet obtained in Porto Rico is somewhat larger than those from Santo Domingo; it is made of marble, with the legs carved in relief and the virile organ conspicuous. The numerous forms of Santo Domingo stone amulets in the Imbert collection vary in size from an inch upward. There are others of shell which will be described later.<sup>1</sup>

#### POTTERY

Although the prehistoric inhabitants of the West Indies were potters, none of their earthenware is of high order. They excelled

<sup>1</sup> For a fuller account of these amulets see *American Anthropologist* (N. S.), vol. 5, October-December, 1903.



1. Side view ; height,  $10\frac{1}{4}$  inches.



2. Top view ; width  $10\frac{1}{4}$  inches.

TRIPPOINTED VASE FROM SANTO DOMINGO.



in relief decoration, practised surface painting only to a limited extent, and were apparently ignorant of glazing. The clay used in their earthenware was coarse, but in some instances the finished product was polished.

The pottery objects vary in form from the shallow platter to the graceful vase, and include bottle-shaped jars and simple double-handled cooking pots. To one of the latter the soot still adhered when found. The most elaborate of all these vessels are the effigy forms, on which the head and other parts of the body are represented in relief. Marks of the coils of clay by which the vessels were built up may still be seen in several bowls. The surfaces were polished with smoothing stones evidently in much the same manner as among the Pueblo tribes of our Southwest.

One of the exceptional forms of Antillean pottery in the Archbishop's collection from Santo Domingo is a vase (plate XLV) with a central prolongation for a neck and two lateral extensions, resembling mammæ, on which decorated nipples appear. The central prolongation appears to have been made separately from the body, and to have been later attached with resin or gum. It is ornamented with eyes, mouth, and other organs in relief. In addition to its rarity in form, this jar is a striking specimen symbolically, the genitals of both sexes being represented in its decoration.

A small flat dish is decorated with a sinuous elevation extending about it, recalling the ornamentation of a fragment of pottery described by Mason. The two bottle-shaped vessels, with their necks ornamented in relief and the surfaces decorated with incised figures, are not duplicated in collections of West Indian pottery. These were obtained from the Archbishop of Santo Domingo.

Among the common objects found in the excavation of caves, village sites, and burial mounds, are many small, burnt-clay heads, often grotesquely human in shape, with protuberant mouths and eyes, suggesting the heads of monkeys, birds, lizards, and other animals. By some writers and many collectors these heads are supposed to be idols and are called *zemis*, but there is good evidence that they are simply relief ornaments from the sides or rims of clay vessels, a perfect one of which, in the form of a shallow bowl, occurs in the Archbishop's collection.

The boat-shaped effigy vase shown in plate XLVI has a projection on one end bearing a face, and ridges or elevations on the sides representing limbs, while the upper surface is ornamented with incised lines forming complex figures. This vase is said to have been found in a cave at Aguas Buenas, in the interior of Porto Rico, but unfortunately the author could not purchase it.

In the collection owned by Señor Neuman, of Ponce, there is a globular effigy vase representing a bird, the wings, head, and broken tail of which are somewhat conventionalized.

A perforated cylindrical roller of terra-cotta, from the Archbishop's collection, has its surface cut with an elaborate design. It is supposed to be a potter's tool and to have been used in transferring patterns to the surfaces of earthenware before firing. A circular clay disk, upon which is graven a simple design, may have been used for a similar purpose.

#### WOOD CARVINGS

The pre-Columbian West Indians were adept in carving, and fashioned many implements, idols, and other objects from the hardest varieties of wood. Their large canoes were manufactured from the trunks of trees, and the highly ornamented paddles by which they were propelled are mentioned by several of the early writers. Cassava-graters, clubs, stools, serpents, idols, and sticks used to induce vomiting are among the specimens of carved wood worthy of description.

*Cassava-graters.*—Flat or curved wooden boards with sharp stones so attached as to make a rough surface on which to grind the root of the manihot are represented in Santo Domingo collections. One of the best of these is owned by Señor Desangles of Santo Domingo city; another, in the collection of Señor Cambiaso, also of Santo Domingo, has the sharp stones fastened to the surface of the curved wooden board in geometric designs similar to those on Carib objects.

*Clubs.*—There are several so-called macanas or aboriginal Antillean clubs in Señor Cambiaso's collection. Although similar implements were undoubtedly used by the Porto Ricans, no specimen has yet been found on that island.

The Smithsonian collection contains a broken ceremonial baton from Santo Domingo, which may be considered under this head. It consists of a shaft of wood, at one end of which is cut an animal figure with a cap shaped like a bird. In general form this cap resembles the stone birds sometimes found in Porto Rico, one of which is owned by Mr. Yunghannis of Bayamon. There is every probability that this baton was used in a way somewhat similar to the staves bearing animal images which were erected by the Indians of Guiana on their burial mounds. A similar custom is described by Gumilla, who mentions the use of like objects in the mortuary ceremonies of the Salivas and other Orinoco tribes.

*Stools.*—The natives of the West Indies made stools or reclining chairs of wood or stone, to which they gave the names *turcy* and





EFFIGY VASE FROM PORTO RICO. (Two-thirds natural size.)



*duho*. These objects were fashioned with great care, sometimes in the form of animals, and often were decorated with much skill. Ten specimens of *duhos*<sup>1</sup> were seen by the author during his visit, five of which were made of wood and five of stone. Eight of the specimens seen were from Porto Rico. One of the two wooden stools especially worthy of mention is in the Imbert collection; the other, which is the best specimen known, belonged to the late Dr. Llenas.

*Idol*.—Señor Imbert possesses a well preserved idol of human form (plate XLVII), different from any yet described. It is made from a log of hardwood, and was once apparently covered with a black pitch, patches of which still adhere to the surface. The idol assumes a sitting posture, with hands on the knees, below which are enlargements representing the bands with which the Caribs bound their limbs to increase their size. The head is provided with a canopy, as in similar wooden figures. Evidently the eyes were of shell or gold, remnants of an adhesive pitch with which they were fastened in place being still visible in the sockets. The head is hollow, or has a cavity which communicates exteriorly by a hole in the back. Possibly a tube formerly connected this orifice with a hidden man who uttered responses to the questions of the priest through the medium of the idol; in other words, we may suppose that the image was sometimes used for oracular purposes, as described by Oviedo and Gomara.

*Serpent*.—One of the most remarkable specimens of West Indian carving is an image of a serpent owned by Señor Eugenio Velasquez of Puerto Plata. It is made of very hard black wood, the smoothly polished surface being decorated with incised geometrical figures. It represents a serpent in a single coil, with head slightly enlarged and tail flattened. The head is well carved and is provided with shallow eye-pits in which stones, shells, or gold nuggets were formerly inserted. The snake-like character of the mouth and nostrils is well represented, but the teeth are indicated only by scratches. On the top of the head is an incised circle and other geometrical figures, and the neck has a collar of incised lines, broken at one point, as is common in Antillean circular figures. Along the back of the body there is a row of four circles alternating with tri-

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<sup>1</sup> The Jibaros of Porto Rico, especially those in the mountains, still use a wooden stool with goat-skin seat to which they give the name *turey*. Probably the best locality in which to procure these modern stools is near Adjuntas, where lives an old man who is very clever in their manufacture. The ornamentation of the modern *tureys* is limited to inlaid work on the back.

angles and parallel lines, their size diminishing and the ornamentation ending a short distance from the tail, which is flattened and not decorated. On the belly there are well carved, smoothly polished scales. This wooden serpent is probably one of those to which early writers refer, and was no doubt highly venerated by its former owners. The object might also possibly have been used in more modern voodoo rites and ceremonies, but as designs upon it are characteristic of those occurring on prehistoric artifacts from the island, there is every likelihood of its ancient character.

*Regurgitating Sticks.*—In describing Antillean ceremonies, early Spanish writers casually state that, in approaching the idols the priests were accustomed to thrust sticks down their throats to induce vomiting, in order that their bodies might be purified before certain rites were performed. This custom, which occurs also in other primitive religions, is mentioned by Gomara, Benzoni, and others, and is illustrated in several early works; the known descriptions and figures of these regurgitating sticks, however, are not detailed enough to convey an idea of their form. In Señor Imbert's collection there are five wooden sticks, consisting of decorated shafts with handles, which were found with the wooden idol already mentioned, hence are believed to have been used in the regurgitation rite. Their shafts are slightly curved, and are flattened and smoothly rounded at their edges, so that they bear a general resemblance to curved paper-knives.

One of the sticks has the handle carved in the form of a kneeling figure, with globular head and with eyes represented by sunken pits in which, the finder claimed, there were nuggets of gold when he obtained the specimen. The fore-legs of the figure, as is customary in such carvings, are placed close to the side of the head. The part of the shaft just below the handle is decorated with incised grooves, ferrules, and other designs.

Another specimen, more elaborate than the first, has a handle carved into an image, the ribs and backbone of which are well indicated. The arms are represented in front of the body, and each hand carries an object different from the other. The feet are more like bird-claws, but the legs have incised lines representing the bands or garters with which the Caribs are said to have girt their limbs to increase the size of their calves. The shaft just below the handle is ferruled, and the incised lines at this point show a break, called the "life line," such as occurs in pottery decorations, idols, and stone pestles. Another of these sticks has a terminal figure with a perforated elevation at the back of the head. Legs are absent, but



WOODEN IDOL FROM SANTO DOMINGO.  
(Imbert Collection; about one-fourth natural size.)



the arms are well made and are flexed at the elbows, bringing the hands to the chest while the fingers are turned to the palms. This specimen also has the broken incised lines on the shaft.

In the other two specimens of these regurgitating sticks there are slight variations in the arrangement of the limbs of the figure forming the handles, otherwise they are generally similar to those described.

#### SHELL AND BONE CARVINGS

Antillean shell and bone carvings are practically unrepresented in the museums of the United States, and little is known of the skill of the aborigines of the West Indies in work of this kind. It is therefore with gratification that the author is enabled to mention a few specimens of shell and bone carving which he was fortunate enough to obtain. The best specimens of this sort that were seen are in the Archbishop's collection from Santo Domingo.

One of the finest examples of shell carving (plate XLVIII, 4) is made of the lip of a conch and was apparently used as an amulet. It consists of a head mounted on a base which is perforated for suspension from the neck or forehead. Great care was given to the carving of both the head and the base, the decoration consisting of cross-hatching and circles. The head is generally globular in form; the eye-sockets are depressions or pits in which gold balls were formerly inserted; while the ears, which are cut in relief, also have pits on the side as if to contain similar ornaments. The technique of the mouth and the teeth is good. The end of the nose is slightly upturned; the back of the head bears incised lines arranged in geometric patterns, following the Caribbean style of decoration.

Another carved amulet, of bone, (plate XLVIII, 5) represents a seated figure with arms akimbo, the hands resting on the knees. Eyes, ears, and appendages to the top of the head are well cut, but the nose is lacking. That part of the figurine which from the front appears to be the neck, is in reality a mouth having rows of teeth, just back of which the object is perforated as if for the passage of a cord by which it was suspended. The details of body and limbs are well worked out, even the umbilicus and leg bands being represented. The general form of this image suggests an amulet for suspension from the body, or perhaps tied to the forehead, a custom which the Caribs are reputed to have observed when they went into battle.

In the Imbert collection there is a flat, rectangular shell plate, about twice as long as broad, perforated at each end. One face of the disk is smooth, but the opposite is decorated with incised circles, dots, triangles, and other figures.

Shell celts, although common in the Lesser Antilles, were not found by the author in Porto Rico; a few, however, exist in local collections, including one owned by Mr. Junghannis of Bayamon, which is almost identical with those from Barbadoes. These objects are generally made from the lip of a more or less fossilized conch.

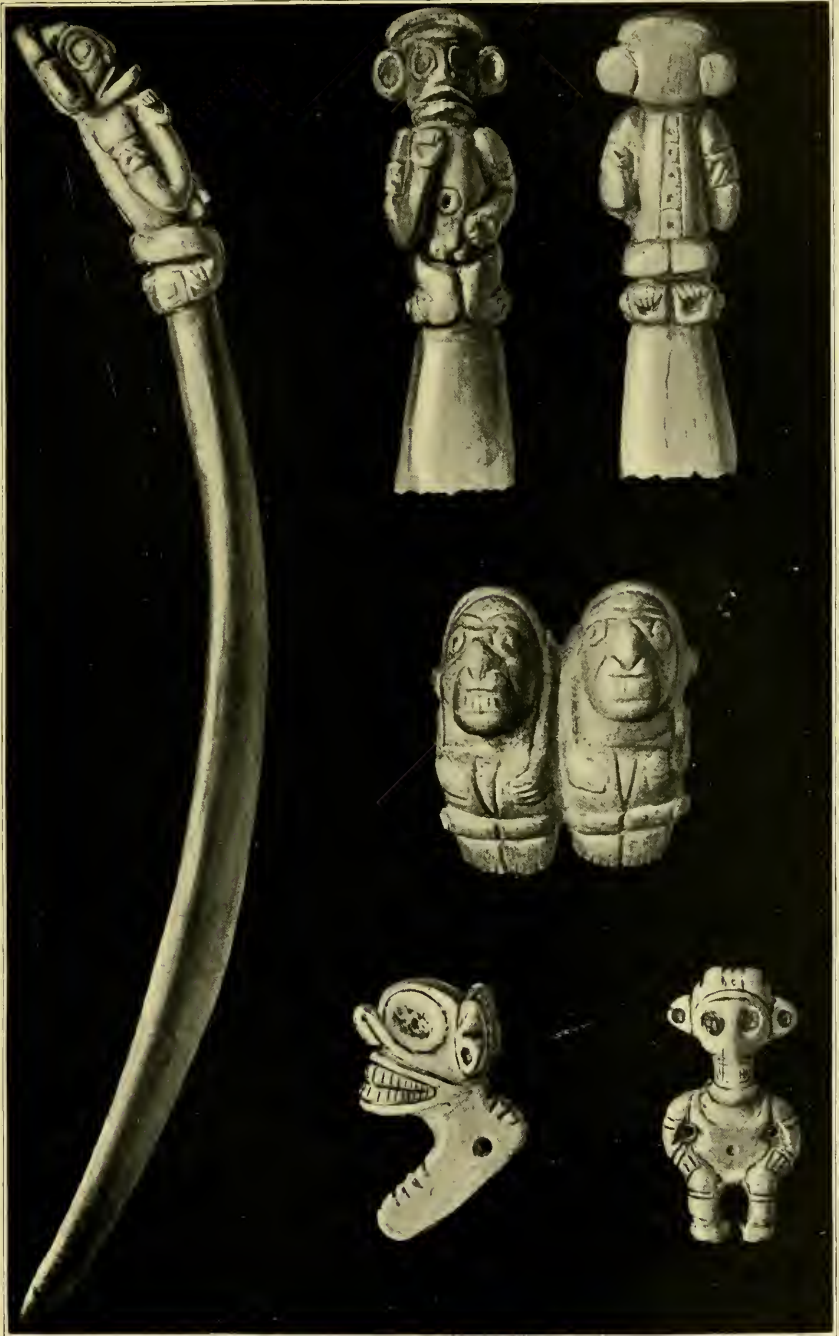
Apparently several genera of living marine shells were highly prized by the prehistoric Antilleans, for tinklers or bells, for beads, etc., and many genera of marine mollusca have been found in graves and caves in the mountain regions of the island.

The finest specimen of bone carving (plate XLVIII, 1, 2), one of the treasures of the Archbishop's collection, was made apparently from the rib of the manati, or sea-cow. It consists of a curved shaft, flat on one side and slightly rounded on the other, and a handle skilfully fashioned into a kneeling figure with a flattened crowned head. The ears are two prominent extensions, with roughened pits or depressions as if for the insertion of fragments of shell or gold nuggets. The position of the eyes is indicated by shallow pits, about the margins of which are concentric rings. The mouth is incised, but is without teeth. The body is smoothly polished; the umbilicus and male genitals are represented, and the waist is surrounded by a band. The vertebræ appear as a row of five shallow, incised rectangles along the middle dorsal line. The arms and legs are well cut; one hand rests on the knee, the other on the chest. The toes are shown on the dorsal side of the image, the soles of the two feet being turned in that direction. The incised lines about the legs and arms represent the bandages with which the Antilleans are said to have bound their limbs. There is a small knob on the outer side of the ankle. A portion of the handle, as well as of the shaft, is stained green, probably caused by its burial in the guano of the cave in which it was found. The author believes this carved rib was used for the same purpose as the wooden regurgitation sticks above described.

In the Nazario collection there is a clavicle with a carved figure forming the handle. This object was also probably used by the priests to induce vomiting.

#### PICTOGRAPHS

There are many rock etchings or pictographs in Porto Rico, particularly on the walls of caves, but as a rule they are more or less obscured by stalagma or vegetable growth. The best preserved examples of picture-writing occur on large boulders near waterfalls or rapids, or along the banks of the rivers, since the rocks on which



## CARVED SHELL AND BONE OBJECTS.

1. Regurgitating stick of bone (side view,  $\frac{3}{4}$  natural size). 2. Front and back views of handle ( $\frac{3}{4}$  natural size).  
 3. Twin amulet of shell ( $\frac{3}{4}$  natural size). 4. Shell amulet ( $\frac{3}{4}$  natural size). 5. Bone amulet (natural size).





they are here cut are not so easily eroded as the softer formations which form the walls of caves.

The author devoted special study to the pictographs near Utuado, at other points along the Rio Grande de Arecibo, and in the caves near Manati, especially in the Cave of the Swallows, previously referred to. These pictographs are usually circular figures representing faces or heads with prominent ears, and sometimes with horns. When, as sometimes happens, bodies are represented, the limbs are appressed to the sides. No animal pictures are to be seen, unless certain zigzag figures may be interpreted to represent snakes. But geometrical figures, as spirals, circles, triangles, and rectangles, are not uncommon.<sup>1</sup>

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<sup>1</sup> For a fuller account see "Prehistoric Porto Rico Pictographs," *American Anthropologist* (N. S.), vol. 5, July-September, 1903.

# FORM-REGULATION IN CŒLENTERA AND TURBELLARIA

By C. M. CHILD

The following is a brief report of the more important results obtained during the author's occupancy of the table of the Smithsonian Institution in the Zoölogical Station at Naples, from July to December, 1903.

Being convinced by study of various fresh-water Turbellaria, and notably of *Stenostoma*,<sup>1</sup> of the possibility of experimental analysis and control of various factors of form-regulation, my chief purpose in visiting Naples was to obtain further evidence along this line. The forms employed for most of the work were the polyclad turbellaria, *Leptoplana tremellaris* and a small species of *Cestoplana*, which, so far as I could determine, was undescribed, and several species of the sea-anemone, *Cerianthus*, especially *C. solitarius*, this species being the most abundant and best suited in other respects for experimental work. In addition an experimental study of regulation in *Tubularia* was made, primarily for the purpose of reëxamining the remarkable regulative phenomena described by other authors. In this work several new results of some importance were obtained.

## I. LEPTOPLANA

This form, one of the more common polyclads about Naples, was already known to possess a high degree of regenerative power. In one respect the relation of regeneration to the nervous system was conspicuous; in no case was a piece able to regenerate a head or cephalic ganglia. All portions of the head removed by cuts anterior to the ganglia or through their anterior portion were rapidly regenerated; if, however, the cut passed just posterior to the ganglia, the anterior regeneration was very slight—only sufficient to heal the wound—and a new head never appeared. Regeneration in the posterior direction was not, however, directly influenced by the presence or absence of the cephalic ganglia. Pieces from the anterior parts of the body, but without cephalic ganglia, regenerated at their posterior ends pharynx, genital organs, intestine, and all posterior parts

<sup>1</sup> Cf. Studies on Regulation, *Roux's Archiv*, 1902-'03.

with the same rapidity as pieces containing the ganglia. It is evident therefore, that there is no direct relation between the presence of the cephalic ganglia and regeneration in general, the presence of the ganglia being necessary merely for the regeneration of the head.

During the course of regeneration the form of both the new tissue and the old parts becomes more or less altered. In specimens without food there is of course a reduction in size, but in addition to this the pieces become relatively longer and more slender ("morphallaxis," Morgan). An extended study of these phenomena was made and distinct confirmation of the conclusions reached in regard to *Stenostoma* was obtained, viz., that this change in form is due primarily to the tension to which the tissues are subjected by the movements of the animal, and especially by the antagonism between attachment to the substratum by the posterior end and the force of the forward movement in consequence of muscular or ciliary activity. The rapidity of this change in proportion depends on the degree of activity of the individual, the rapidity and frequency with which it moves about, and consequently the longitudinal tension to which its tissues are subjected. One case serves as an illustration: Pieces deprived of the cephalic ganglia are incapable of carrying out the typical creeping movements; they are able to advance very slowly after strong stimulation, but remain quiet most of the time when undisturbed. As was noted above, absence of the cephalic ganglia does not directly affect regeneration at the posterior end of a piece. With these two facts in mind, two sets of pieces were prepared, the posterior ends of all pieces representing the same level (anterior to the middle) of the body. From one set heads and cephalic ganglia were removed; the other set retained these organs uninjured. The pieces of the latter set moved about actively, those of the former showed scarcely any power of movement. In the latter set the bodies, and especially the plastic regenerated tissue, gradually assumed a tapering form with greatest breadth at the anterior end and pointed posteriorly. The pieces of the set without cephalic ganglia regenerated from the posterior cut surface, but the new tissue grew out in a rounded mass and neither new nor old tissue ever acquired a tapering form. Various other methods of attacking the problem were employed, and all with the same result.

It was found that pieces of a certain shape would move in circles after the extensive contraction of the cut surface had taken place, this movement being due to the one-sided effect of the cilia. In such pieces the regeneration occurred as usual from the posterior cut surface; the new tissue, however, did not grow out in the direction of

the longitudinal axis of the body, but the direction of its growth depended entirely on the direction of movement of the piece. In this manner specimens were obtained in which the tip of the regenerated tail was overlapped by the head. The body was not simply temporarily bent, but it was impossible for the animals to straighten themselves. The new tissue had grown out at an angle to the longitudinal axis, the size of the angle varying inversely as the size of the circle in which the piece moved. In other words, the regenerating tail being used constantly for attachment was subjected to tension, but, owing to the circular movement of the piece, this tension was not in the direction of the longitudinal axis, but formed an angle with it. The tension was effective either directly or indirectly in determining the arrangement of the tissue.

All of these facts and many others observed show the great influence of mechanical factors in determining the form of these animals.

It may be said that in *Leptoplana*, as in *Stenostoma*, the characteristic form or outline of the body is determined by mechanical conditions of tension. In the normal environment, however, these conditions depend on the characteristic activity of the animal and the characteristic properties of its tissues. From this point of view the forms may be regarded as predetermined, but even so, only indirectly, since it is the result rather than the cause of function. These problems will be discussed more fully at another time: here it is possible only to call attention to them briefly.

## II. CESTOPLANA

The species of *Cestoplana* employed was a small white form averaging about 10 mm. in length and less than 1 mm. in transverse diameter. A slightly differentiated head with a number of eyes was present. Posterior to the cephalic ganglia the much-branched intestine filled the whole body: the pharynx was situated in the middle region of the body with some slight variation in position.

In general regenerative power this form differed widely from *Leptoplana*. In no case did extended growth in the posterior direction from a cut surface occur: the wound healed and a very small bud of new tissue appeared, but this was all. The result was the same whether only a small portion had been removed from the posterior end of the body or all except two or three millimeters at the anterior end.

From an anterior cut surface, anterior to the brain, new tissue

grew out, replacing the parts of the head removed. Moreover, in this form regeneration of the cephalic ganglia was possible.

The difference between this form and *Leptoplana* in this respect may perhaps be due, as has been suggested by others in connection with somewhat similar phenomena in other forms, to differences in the degree of cephalization of the nervous system.

Though *Cestoplana* does not give rise to a large amount of new tissue after injury, it completes regeneration in another way, viz., by the formation of the missing parts within the portions of the body still remaining. In pieces without a pharynx a new pharynx regenerates (with certain exceptions noted below) within the old tissue at greater or less distance from the end. Its position in any particular case depends on the region of the body from which the piece in question was taken. In pieces taken from the region anterior to the old pharynx the new pharynx regenerates in the posterior half of the piece. The further anterior the level which the posterior end of the piece represents, the nearer the posterior end is the new pharynx. In pieces posterior to the old pharynx, the new pharynx appears near the anterior end of the piece, provided this represents a level not far posterior to the old pharynx: in pieces from the extreme posterior end of the body, no pharynx is regenerated. I am inclined to believe that the position of the pharynx is determined by the movements and pressure of the internal contents: the grounds for this belief cannot be given at present. A somewhat similar, though not identical explanation has been offered by Bardeen for the position of the regenerating pharynx in *Planaria*.

The pieces of *Cestoplana* undergo a marked change in form, becoming relatively longer, more slender, and tapering posteriorly. Here, as in *Leptoplana*, the change in form can be shown to be due to the longitudinal tension to which the tissue is subjected in consequence of the antagonism between forward movement and attachment by the posterior end to the substratum. In the posterior portions of the body where this tension is greatest the elongation is often so great that the intestine is torn apart and undergoes disintegration.

One of the most interesting phenomena observed in this form was the disintegration and disappearance of portions of the intestine in specimens kept without food. In such specimens kept for a few weeks in clear water the branches of the intestine in the anterior and posterior regions of the body gradually lose their dark color and become indistinct. Examination under a high power shows that the tips of these branches are actually disintegrating; the cells and

granular masses are clearly visible in the region previously occupied by the branch and in the interstices of the parenchyma. In the course of two to three months this disintegration proceeds so far that in the terminal regions of the body only an unbranched axial intestine remains intact. Meanwhile the disintegration of the lateral branches is advancing from the terminal regions toward the middle region of the body: the branches in the pharyngeal region are the last to show traces of disintegration. This disintegration and disappearance of intestinal branches appear to be essentially atrophy as the result of disuse. In the absence of food the intestinal contents diminish in quantity, and in the course of time become insufficient to fill the whole intestine, even to a moderate degree. Those parts of the intestine which are least often expanded by contents, or from which the contents are most frequently forced out by contraction of the body, viz., the terminal regions, are the first to undergo atrophy. The atrophy gradually extends toward the middle region, those parts near the pharynx being the last affected. This fact indicates that Bardeen is correct in his belief that the pharyngeal region is a region of "greatest intestinal pressure." The axial intestine does not undergo atrophy, though it is often reduced in size, especially its terminal portions. Even after several months it contains a thick, dark, granular fluid, which is forced to and fro in it by the contractions of the body. Probably the stimulation of the intestinal walls by this fluid is sufficient to prevent disintegration of this part of the intestine.

A very interesting modification of this process of atrophy was observed in numerous pieces from the posterior region of the body, which were kept for four months or more. These pieces did not regenerate a head or pharynx: they showed little power of movement beyond peristaltic contractions, and there was no communication between the intestine and the exterior. In the course of about three months all lateral branches of the intestine had completely disappeared, leaving only a straight, unbranched axial intestine. Within the axial intestine in every case was found a fluid or semi-fluid residue, either of the intestinal contents, or of disintegrated portions of the intestinal wall, or of both. This residue, dark in color and filled with granules, is forced to and fro in the axial intestine by the contractions and movements of the piece. During all this time the piece is of course decreasing in size, but the dark residue in the axial intestine apparently does not decrease in quantity after a certain time. Undoubtedly all nutritive substances have been removed from the fluid long before this, and probably equilibrium as regards

diffusion has been established: there remain only waste products, débris, etc. Now, as the piece decreases in size a point is reached where the intestinal space is reduced to such an extent that the residual fluid fills it completely and begins to exert a pressure upon its walls. The changes following this period are most remarkable: from the sides of the axial intestine a new set of lateral branches begins to grow. These are typical intestinal branches, not ruptures or masses of disintegrating cells. The entrance into and exit from these branches of the residual fluid can be clearly observed. Moreover, they are not the old branches: it might be believed that the old branches had not actually disintegrated, but had merely become invisible as the result of collapse and were now become visible again because distended. This, however, is not the case; these new branches are less numerous and farther apart and much more delicate than the old branches, but they are unmistakably intestinal branches. This formation of a new set of intestinal branches was observed repeatedly in pieces of the kind described, which were kept for several months. It is of considerable importance as indicating how closely typical structure of this organ is dependent upon its typical function. So close is this dependence that typical structure cannot continue to exist when the typical function is abolished. One further point may be merely suggested here; viz., the possibility that the functional stimulus may be a mechanical tension exerted on the intestinal walls by the fluid contents.

### III. CERIANTHUS

The body of *Cerianthus* is elongated and almost cylindrical in form, except aborally where it tapers to a blunt point. The course of regeneration, and indeed the possibility of regeneration, is determined to a large extent by the shape of the piece. In pieces cut from the body the body-wall soon begins to roll inward at the cut surface, this change being due not to muscular contraction, but to the elasticity of certain layers of the body-wall, apparently the mesogloea, at least in large part. In cylindrical pieces inrolling of the ends only occurs and typical regeneration is possible. In pieces slit longitudinally or in strips cut from the body the inrolling may often be spiral or transverse and typical regeneration impossible.

In cylindrical pieces regeneration is typical and complete, resulting in a new individual of smaller size than the original and differing from it more or less widely in form. Complete regeneration is possible in pieces which comprise only a small fraction of the whole, provided they are in the form of rings of tissue. Such pieces, about

one twentieth of the body-length, have been observed to regenerate completely.

The rapidity of regeneration is greatest at the oral end and decreases aborally, until in a short aboral region complete regeneration does not occur. Apparently the power of growth and in general the reactive capacity of the tissues are greatest at the oral end and decrease aborally.

Rapidity and amount of regeneration are influenced by temperature, increasing with rise and decreasing with fall of temperature. This influence of temperature is clearly seen in the difference in the rapidity and amount of regeneration in summer and in winter, the temperature of the water being much lower during winter.

In pieces above the minimum, size has no effect on the rapidity of regeneration and only a very slight effect in the later stages upon the amount. In other words, the new parts are far from being proportional to the size of the piece from which they arise. A piece five millimeters in length produces tentacles of about the same length as a piece twenty or thirty millimeters in length. Only after several weeks does the smaller piece fall slightly behind the larger. These facts make it evident that proportionality is by no means retained in the regenerating pieces of *Cerianthus* and are therefore difficult to reconcile with those theories in which this proportionality plays an important part.

It was found to be possible to analyze to a certain extent the process of regeneration and to inhibit it experimentally. The more important results obtained from these experiments are given briefly in the following paragraphs.

As regards the growth of tissue from cut surfaces of the body-wall, it was found that new tissue arising from cut surfaces appears to obey the laws of capillarity to some extent. New tissue was never seen to grow out from a single exposed cut surface; the surface may heal over, but no further growth occurs. When, however, two cut surfaces are in contact, union between them occurs, and the growth thus initiated may continue in the form of a thin membrane with concave free margin for a certain distance between two diverging cut surfaces. The distance to which the membrane is capable of extending depends, in a given species of *Cerianthus*, on the angle of divergence of the cut surfaces—the greater the angle the less the distance over which the new membrane of new tissue can extend. It follows that if the angle of divergence be too great for the extension of this membrane, the wound cannot close. Thus, by preventing contact of cut surfaces or by fixing their position at a



certain angle, the closure of wounds can be experimentally prevented or stopped at any point. The relation between extent of the new tissue between diverging cut surfaces and the angle of divergence of these surfaces, as well as the concave free margin of such new tissue are comparable with the behavior of fluid films under similar conditions. This new embryonic tissue certainly contains a high percentage of water, and it is not at all improbable that the laws of capillarity should determine its behavior to a greater or less extent.

The second point of importance in the experimental analysis of regeneration concerns the influence of water-pressure on regeneration. As is well known, *Cerianthus* is essentially a hollow sac with a mouth at one end; the sac is divided peripherally into chambers by the mesenteries; a hollow marginal tentacle opens orally from each one of these chambers, and most of them communicate also with a smaller labial tentacle. Under normal conditions, and when undisturbed, the body and tentacles of the animal are distended by the water in the enteron, which is under a considerable degree of pressure. When a cut is made in the body-wall, or a piece is removed, collapse of body and tentacles occurs at once. As I shall show in detail elsewhere, this is due simply to escape of water from the enteron and not at all to a change in osmotic conditions, as Loeb<sup>1</sup> believed. Typical regeneration of pieces can never occur unless the piece can in some manner acquire again the form of a sac in which water can be retained under pressure. If closure of the aboral end of pieces be prevented by repeated artificial separation of the cut surfaces, the appearance of the tentacles at the oral end is delayed. If the piece be allowed to close until small tentacle-buds have appeared, and then be opened at the aboral end and kept open, growth of the regenerating tentacles ceases, and they may even decrease in size. In every case the delay or inhibition continues as long as an opening is present which prevents distension of the body by water and pressure upon its walls. As soon as the openings are allowed to close, the interrupted regeneration continues. The objection may be made that the pressure of the water in the enteron will be the same in all regions of the body, and that it cannot account, therefore, for the localization of organs at certain regions. To this the answer may be made that currents in definite directions are caused in the enteron by the vibrations of cilia and that these currents striking the wall at certain points may produce characteristically localized differences in pressure. It is highly probable, as I shall show else-

<sup>1</sup> *Untersuchungen zur physiologischen Morphologie*, 1, 1891.

where, that the position of regenerating tentacles is determined in this manner.

It is possible also to reduce the fully grown tentacles of normal animals to mere stumps by keeping the aboral end of the body continuously open. After the tentacles have remained collapsed for a time, the tips begin to shrivel and are gradually absorbed until only stumps remain. If, now, the aboral end of the body be allowed to close, the enteron once more becomes distended with water, and the tentacles, being again distended, gradually grow out again. Many other instances of the close relation between growth and the pressure of the water in the enteron were observed, but their description must be deferred.

The chief results of my work on *Cerianthus* may be summed up in the statement that regeneration in *Cerianthus* is influenced in large measure by simple mechanical conditions of pressure and tension, and that in the absence of these conditions in typical amount and localization, typical regeneration is impossible.

#### IV. TUBULARIA

A part of the work on *Tubularia* consisted of the reëxamination of certain regulative phenomena described by other investigators. My conclusions differ from theirs in various points, but a critical discussion may be omitted here.

A few points of interest which are either new in themselves or afford new interpretations of known facts may be mentioned briefly. It was found that in many instances the pieces cut from the stems of *Tubularia* would produce a stolon at the aboral end, and if they were in contact with a solid body would become attached in a few days. In many cases these stolons attained a length of fifteen millimeters or more and frequently became branched. In the course of time most of the branches of the stolon, and often even the tip of the main stolon, turned upward away from the substratum and developed new hydranths in the usual manner. If the stolon did not come into contact with a solid surface within a day or two after its formation, the end usually produced a new hydranth in a much shorter time than when it succeeded in attaching itself to a surface. This power to produce stolons is found only in the more vigorous stems, and long pieces are more likely to produce stolons than short pieces.

The formation of a hydranth at both oral and aboral ends of pieces from the stem of *Tubularia*, or the formation of a hydranth at the oral end and nothing at the aboral end, have been described by a

number of authors as the usual methods of regeneration. In case two hydranths are formed, the oral appears earlier than the aboral. The formation of stolons at the aboral end in vigorous pieces, as described above, indicates that the aboral end of the piece is more or less "determined" for stolon-formation. It is probable, therefore, that the delay in the formation of the aboral hydranth in pieces which have not formed a stolon is due to the time required for the changes preparatory to hydranth-formation instead of stolon-formation. The production of stolons by certain pieces and the production of hydranths from the ends of the stolons when attachment is impossible, or much later, after the stolon has become attached, appear to be reactions to unfavorable conditions. Only vigorous pieces form stolons at all; *i. e.*, in pieces less vigorous the stimulus to hydranth-formation overcomes the stimulus to stolon-formation before the latter becomes effective. Now, in the vigorous pieces which have produced stolons, the stolon itself, when subjected to unfavorable conditions, develops a hydranth at its tip. Somewhat similar phenomena have been observed in other hydroids.

An extended study was made of the proportions of both normal and regenerated hydranths from various regions of the stem: this included measurements of regenerating hydranths before their emergence from the perisarc, as well as of fully-developed hydranths. At least four different dimensions were measured in each case. Comparison of the measurements of hydranths from different regions shows that their proportions are characteristically different. Hydranths arising from the extreme oral end of a stem possess different proportions, both before and after emergence, from those arising at the oral end of a piece from the middle or basal portion of the stem. The proportions of aboral hydranths are different from those of oral hydranths, and also differ among themselves, according to the region from which they arise. The form of the hydranth is then not the same under these different conditions of origin: on the contrary, there are characteristic differences corresponding to the different conditions.

These facts indicate that the various conditions play a part in determining the form of the result in each case. Discussion of their theoretical bearing is reserved until the data can be given in detail.

In conclusion I desire to express my most sincere thanks to the Smithsonian Institution for the opportunity afforded me of carrying on the work above described.

HULL ZOÖLOGICAL LABORATORY, UNIVERSITY OF CHICAGO,  
August, 1903.

NEW GENERA OF SOUTH AMERICAN FRESH-WATER  
FISHES, AND NEW NAMES FOR SOME  
OLD GENERA

BY CARL H. EIGENMANN

In attempting to define the genera of the South American Heterognaths it was found that a number of new genera deserve recognition, and that the names of some of the best-known genera are preoccupied by the earlier use of the same names. In the following pages the new genera are briefly defined and new names are suggested where needed. The relationship of the new genera will be pointed out in a general work on the Heterognaths which was begun sixteen years ago and which it is hoped will soon be finished.

1. *ANISITSIA* Eigenmann & Kennedy

New genus of Chilodinae allied to *Hemiodus*.

Third suborbital not enlarged. Teeth in upper jaw flat, serrated; no teeth in lower jaw. Scales below the lateral line much larger than those above it; scales moderate or large.

*Type*.—*Anodus notatus* Schomburgk.

Named for Prof. J. Daniel Anisits, of the University of Paraguay.

2. *LAHILLIELLA* Eigenmann & Kennedy

New subgenus of *Anostomus*.

Teeth in lower jaw in a single series, multicuspid. Lateral line complete, faint. Dorsal over ventrals. Nares remote. Snout broad, subelliptic in cross-section. Mouth directed obliquely downward and forward, lower jaw the shorter.

*Type*.—*Schizodon nasutus* Kner.

Named for F. Lahille, of the Museo de la Plata.

3. *HOLOSHESTHES*

New genus of Tetragonopterinae, allied to *Cheirodon*.

Premaxillaries and mandible with a single series of many-pointed incisors; maxillaries with teeth along its entire edge. Lateral line complete.

*Type*.—*Cheirodon pequirá* Steind.

ὄλος, entire; ἕσθῆς, a garment; in allusion to the complete dentition of the maxillary.

#### 4. HOLOPRION

New genus of Tetragonopterinae, allied to *Aphyocarax*.

Premaxillary and mandible with a single series of pointed teeth with minute cusps on each side; maxillary with teeth along its entire edge.

*Type*.—*Cheirodon agassizii* Steind.

ὄλος, entire; πριων, a saw.

#### 5. HOLOPRISTIS

New genus of Tetragonopterinae, allied to *Hemigrammus*.

Premaxillary with two series of teeth, their crowns ridged, those of the inner series equal; maxillary with teeth along its entire edge. Lateral line interrupted. Gill-rakers setiform. No predorsal spine.

*Type*.—*Tetragonopterus ocellifer* Steind.

ὄλος, entire; πριστής, one who saws.

#### 6. MARKIANA

New genus of Tetragonopterinae, allied to *Pacilurichthys*.

Premaxillary with two series of teeth, their crowns ridged, the teeth of the inner series equal; maxillary without teeth. Lateral line complete. Gill-rakers setiform. No predorsal spine. Depth more than 2 in the length. Anal and caudal scaled; anal long, its margin rounded. Scales large, with 7–20 notches. Dorsal distinctly behind the ventrals.

*Type*.—*Tetragonopterus nigripinnis* Perugia.

I take pleasure in dedicating this genus to my friend and teacher, Dr. Edward L. Mark, for more than twenty-five years at the head of the Zoölogical department of Harvard University.

#### 7. MOENKHAUSIA

New genus of Tetragonopterinae.

Similar to *Markiana*. Anal naked, caudal scaled.

*Type*.—*Tetragonopterus xinguensis* Steind.

For my colleague, Dr. Wm. J. Moenkhaus, formerly of the Museu Paulista, São Paulo, Brazil.

#### 8. OTHONOPHANES

New genus of Tetragonopterinae, allied to *Brycon*.

Premaxillary with three series of teeth. Scales equal. Lower lip very broad, pendant.

*Type*.—*Brycon labiatus* Steind.  
*οδονγ*, a napkin; *φανω*, to show.

#### 9. *BRYCONODON*

New genus of Tetragonopterinae, allied to *Brycon*.

Premaxillary with three series of teeth. Scales equal. Lower lip normal; lower jaw without an inner series of teeth. Ventrals in front of dorsal; anal long, of about 29 rays.

*Type*.—*Bryconodon orthotania* Günther.  
*βρωζω*, to devour; *οδους*, tooth.

#### 10. *STICHONODON*

New name for *Lütkenia* Steindachner, 1876, preoccupied in *Crustacea* Claus, 1864.

*Type*.—*Lütkenia insignis* Steind.  
*στενω*, to set in a row; *οδους*, tooth.

#### 11. *EVERMANNELLA*

New genus of Hydrocyoninae, allied to *Cynopotamus*.

No teeth on palate. Belly rounded. Dorsal behind ventrals. Lateral line complete. Lower jaw with two series of teeth, those of the outer series not regularly decreasing in size. Anal with more than 40 rays. No canines.

*Type*.—*Cynopotamus biserialis* Garman.

For Dr. Barton Warren Evermann, of the United States Fish Commission.

#### 12. *ACESTRORHYNCHUS*

New for *Xiphorhynchus* Agassiz, 1824, preoccupied in *aves* Swainson, 1827, and *Xiphorhamphus* Müller & Troschel?, preoccupied in *aves*, 1843.

#### 13. *ACESTRORHAMPHUS*

New genus of Hydrocyoninae.

A single series of conical teeth on the palatines; lateral line complete; belly rounded; dorsal fin behind middle of the length; scales moderate, 47–75 in the lateral line. Maxillary without canines, not sheathed under preorbital, dentaries not in contact along the median line below. Gill-rakers setiform.

*Type*.—*Hydrocyon hepsetus* Cuvier.  
*ακειςτρα*, a thick needle; *ραμφοζ*, snout.

14. *BOULENGERELLA*

New genus of Hydrocyoninae, allied to *Xiphostoma*.

Teeth on palate minute, granular. Belly rounded. Snout greatly produced, conical. Premaxillary and mandible very long, with a single series of very small, equal, recurved teeth. Scales small. Lateral line incomplete. Anal short, of 10 or 11 rays.

*Type*.—*Xiphostoma lateristriga* Boulenger.

For Dr. G. A. Boulenger, of the British Museum.

15. *GILBERTELLA*

New genus of Cynodontinae.

Origin of dorsal above anal; anal with about fifty rays; pectoral very long, reaching beyond origin of anal. Lower jaw with a pair of canines on each side, of which the outer one is larger; a pair of small canines behind the front series in front; teeth otherwise in a single series.

*Type*.—*Anacyrtus alatus* Steind.

For Dr. C. H. Gilbert, of Leland Stanford Junior University.

16. *ACNODON*

New genus of Mylesinae.

Premaxillary teeth with an oblique, cutting edge, in two series. No abdominal serræ in front of the ventrals. Gill-rakers filamentous. No predorsal spine.

*Type*.—*Myleus oligocanthus*, Müller & Troschel.

*a*, privative; *κνωδων*, projections on a hunting spear.

17. *MYLEOCOLLOPS*

New subgenus of *Metynniss*.

Premaxillary teeth with an oblique, cutting edge, in two series. Abdominal serræ along the entire ventral surface. A procumbent dorsal spine. Adipose fin long; dorsal of less than 20 rays; free margin of anal convex, or with a single lobe in front. Gill-rakers short, not setiform.

*Type*.—*Metynniss goeldii* Eigenmann = *Myletes lippencottianus* Ulrey, not Cope.

*Myleus*, name of an allied genus; *κολλοψ*, ridge of skin on neck of horse.

18. *PIARACTUS*

New genus of Mylesinæ, allied to *Myleus* and *Colossoma*.

Premaxillary teeth with an oblique cutting edge, in two series. No procumbent predorsal spine; adipose fin rayed; free margin of anal convex, without lobes.

*Type*.—*Myletes brachypomus* Cuv.

πίαρ, fat; ἀκτις, a ray.

19. *ORTHOMYLEUS*

New subgenus of *Myleus*.

Differing from typical *Myleus* in having the dorsal rays not prolonged into filaments.

*Type*.—*Myletes ellipticus* Günther.

ορθος, straight; *Myleus*.

20. *COLOSSOMA* Eigenmann & Kennedy

New genus of Mylesinæ, allied to *Myleus*.

Premaxillary teeth with an oblique cutting edge, in two series. No procumbent predorsal spine; adipose dorsal not rayed; anal naked, its margin straight or convex.

*Type*.—*Myletes oculus* Cope.

κολός, without horns (predorsal); σωμα, body.

21. *MYLOSSOMA* Eigenmann & Kennedy.

New genus of Mylesinæ, allied to *Myleus*.

As in *Colossoma* but with the anal scaled, its margin convex, without lobes, the rays of the posterior third longest. Gill-rakers rather long, numerous.

*Type*.—*Myletes albiscopis* Cope.

μυλος, a millstone; σωμα, body.



## KOREAN HEADDRESSES IN THE NATIONAL MUSEUM

By FOSTER H. JENINGS<sup>1</sup>

Among the many customs peculiar to quaint Korea, the style and manner of wearing the hat is probably the most noticeable. Fashions there seem never to change, for many styles of hats of to-day are of the same material and shape as those of the days of the Ming dynasty, or of the days of Confucius. The people have hats for all ranks and for all occasions—there are hats for the nobility, for the gentry, for petty officers, for chair bearers, and for almost every ceremony—and perhaps no nation has more ceremonies than the Koreans. There are also hats worn when a person reaches manhood, others for use during ancestral worship, for passing the civil service examination, during betrothal, at marriage, while mourning, and for making official visits to high dignitaries. The hat is in fact a badge of honor and its absence a sign of disgrace.

For many years butchers were not allowed to wear hats, the Buddhist religion making it a sin to take the life of any living creature. In 1895, however, a petition was presented to the Home Department of the Korean government asking that public notice be given throughout the eight provinces that butchers be allowed to wear hats the same as other citizens and that they be free from molestation. The preamble of the petition stated the grievances of the butchers: how for five hundred years, although guilty of no crime against their country, they had been grievously oppressed. The government promptly granted the petition. Upon being notified that their request had been allowed, a butcher named Pak, who had prepared the petition, wrote to the country butchers informing them of their approaching deliverance and warning them against

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<sup>1</sup>The author of this paper was a young man of great talent and promise. He was a skilful artist, and when a mere boy often visited the National Museum for the purpose of sketching and study. Through his deep interest in Oriental, and especially in Korean, subjects, he became acquainted with the attachés of the Korean legation, who, impressed by his usefulness, caused him to be made an official of the fifth grade, in which capacity he was employed at the time of his death, January 15, 1900.—W. H.

becoming puffed up by their sudden elevation in rank. A month later placards announcing that the petition was granted were posted throughout the country. The butchers in Seoul had for some months been allowed to wear hats; but if a country butcher wore one, he was greeted by some such remark as "You dog of a butcher, what are you doing wearing a hat like one of us?" Butchers are considered lower than beggars, as it is said "something might be made out of a beggar, but it is impossible for a butcher ever to rise."

When a boy attains the age of seven years he starts a topknot, which when grown is never changed in form as long as he lives. The topknot was the cause of an amusing episode in Seoul in



FIG. 3.—Headband and topknot. (No. 77,112, U. S. N. M.)

1895. Like many other nations when first adopting European customs, the Koreans went to extremes. An edict was issued that all topknots should be cut off, and, as the people naturally objected, soldiers were sent out in the city to forcibly cut off all topknots that had not been removed in compliance with the edict. This created such consternation that farmers would not bring their produce to the city markets, and such suffering resulted from want of food that the edict was abrogated and topknots were once more in full favor.

Every Korean, at all times, day and night, wears a band around the head (fig. 3). The hats are perched on top, never low on the head, and are secured by pins (fig. 4) to the topknot and by strings tied under the chin. Among the nobility, circular or ring-shaped

insignia of rank, about half an inch in diameter, are worn back of each ear and fastened to the head by a string (fig. 5). Five grades of nobility are thus represented: (a) *Tā-kum*, first rank, smooth white jade; (b) second rank, smooth gold; (c) *Young-kum*, third rank, carved gold; (d) fourth rank, carved white jade; (e) *Na-ri*, fifth rank, tortoise shell (anciently of silver). The button of the royal family is of smooth green jade.

The national hat of Korea (*kat*) is made of fine silk over a bamboo framework, stiffened with size (fig. 6). It has a small, cylindrical, truncated crown and a broad brim with long tying strings. The diameter of the brim is 18 inches and the height of crown  $4\frac{1}{2}$  inches. In ancient times the brim was, by royal edict, very much wider to prevent conspirators from whispering to each other, the stiff brims keeping them some distance apart. This illustrates a national characteristic of Koreans, their suspicion of every one, and it will be many years

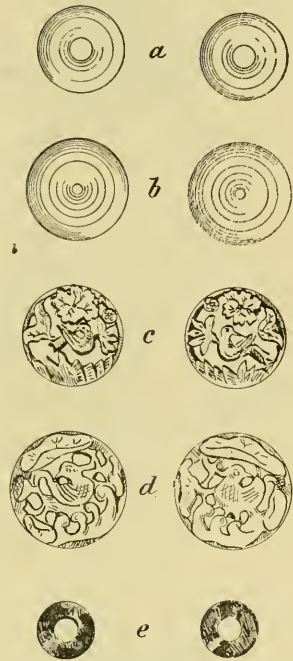


FIG. 5.—Buttons for headband denoting rank of nobility. (About  $\frac{2}{3}$  nat. size.)

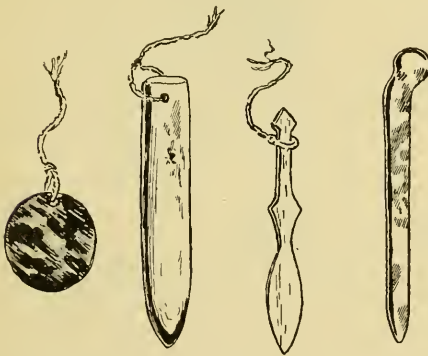


FIG. 4.—Hatpins for topknot. ( $\frac{2}{3}$  nat. size.)

before this universal peculiarity is eradicated in this otherwise kind, genial people. The *kon* is a wide, circular band of black horsehair,  $7\frac{1}{2}$  inches high, worn by those of the literary class who have not yet passed a civil service examination or held office (fig. 7). It may also be worn by one who passes the second grade of merit at the literary or military

examinations before holding office, but the lower class of merchants and laborers, unless after such examination, cannot wear it.



FIG. 6.—National hat. (No. 77,060.)



FIG. 7.—House hat. (No. 77,056.)

In the Korean civil service examination, one of the requisites is the examination cap, or *yu kon*, composed of a piece of coarse black cotton stuff, shaped like a grocer's paper bag, 9 inches high and 7 inches in diameter. It is worn by students only at the literary examinations, held yearly for the preliminary grade (fig 8). This hat is reputed to be made in the shape of the mountain near which Confucius was born, and was introduced from China several centuries ago, probably during the Ming dynasty.



FIG. 8.—Civil service examination hat. (No. 77,057.)

The court or official hat, *samo*, is 7 inches high with a high terraced crown of stiff lacquered paper and woven bamboo, covered with black sateen (fig. 9). It fits tightly over the forehead, and at the back on either side there are curved, ear-shaped wings of gauze that project horizontally forward. This is practically the coronet of Korea and can be worn only by the nobility on official occasions, but officers of the government wear such hats during an audience with the King. The wings are said to have been made to resemble ears bent forward in the act of listening to catch every word of command the King may utter. The royal hat or crown

of the King of Korea is of the same shape as the *samo*, except that the wings are vertical instead of horizontal, indicating that the king receives his commands only from Heaven. The Koreans are great lovers of Chinese classics, and like all peoples of the far east, attach poetical names to everything. The gauze wings on the official hat are called the "wings of the locust." The Chinese poet says, "like the locust singing in the tree with love and peace toward all men," and as the locust is the emblem of peace, the royalty and men of noble rank, who are supposed to spend their time seeking peace and the welfare of their country, wear the locust-wing emblems on their headdress.



FIG. 9.—Official hat. (No. 202,889.)

Perhaps the most elaborate of Korean hats is the one worn by the king's assistants when he offers sacrifices. This is helmet-shaped and is skilfully woven of thin strips of bamboo encrusted with gilt papier-mâché dragons, scrolls, and other emblems. It is fastened to the head by a large hatpin, with cords and tassel, thrust through the sides and back of the hat (fig. 10).

A hat that seems to be prescribed for the bridegroom at the time of the wedding ceremony is shown in figure 11. It is made of lacquered paper, covered with silk cut and folded into a wedge



FIG. 10.—Ceremonial hat. (No. 77,058.)



FIG. 11.—Wedding hat. (No. 202,886.)

shape, and depending from the back are three double tassels of red silk.

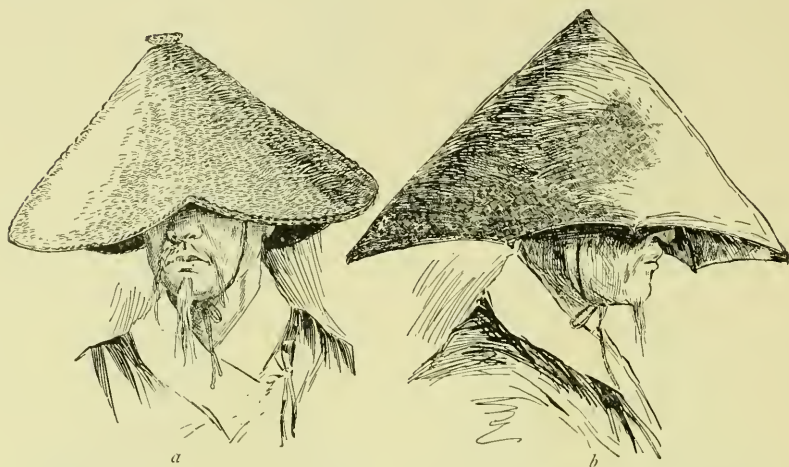


FIG. 12.—*a*, Mourner's hat (No. 77,066). *b*, Farmer's hat (No. 77,065).



FIG. 13.—Mourner's hat and headband. (No. 77,089.)

The largest hat worn in Korea is that of the farmer (fig. 12, *b*). It is conical, with hexagonal base, and is woven of split stalks of



millet. The exterior and interior of the straw are of different color and form a pleasing variety in the weave. It is stoutly braced inside with hoops of bamboo and gives effective protection against wind and storm.

Confucianism prevails among the higher classes in Korea and its influence permeates all classes of citizens. Confucius gave the order that mourning for three years should be worn for the loss of either parent, a custom strictly followed by Koreans. White is a mark of mourning, and all articles of mourning costume are covered with sack-cloth. The mourning hat, or *jang gat*, is largely



FIG. 14.—Royal chair-bearer's hat. (No. 202,886.)

in evidence in Korea (fig. 12, *a*); it is made of bamboo splints, the edges scalloped and finished with braiding, and is crowned with a rosette of bamboo. A frame to fit the head is fastened inside, and from it hang tying strings of twisted paper. It is 14 inches high and of 25 inches diameter, and is designed to hide the face, it being considered a grievous breach of etiquette to look into the face of a mourner. Taking advantage of this custom before Korea was opened to foreigners, Jesuit priests disguised themselves as mourners and lived among and taught the people for a long time

without detection. When the King dies, the nobility wear the *samo* in white (fig. 9). In the house and at a certain period the mourner wears a cap and head-band like that shown in figure 13.

The royal chair-bearers are trained from youth to carry a palanquin with a quiet, swinging motion free from jar. They wear one of the most peculiar of Korean hats (fig. 14), made of several thicknesses of brown paper, covered with purple satin, the front decorated with designs in silver paper, and from the top hangs a piece of gauze silk 5 inches long by 4 inches wide. The hat is  $\wedge$ -shaped, 10 inches high, 5 inches wide at the apex, and  $4\frac{1}{2}$  by 6 inches square at the base.



FIG. 15.—“Fly’s head” hat. (No. 202,888.)

The official assistant’s hat, or *pare murce*, shown in figure 15, is of delicately interwoven horsehair and strips of bamboo covered with black silk. It is cylindrical in shape, 6 inches high, 7 inches in diameter, and is known among the Koreans as the “fly’s head.” The position of official assistant, or *shu re*, can hardly be explained to the European. He is a kind of secretary, superintendent, and general factotum for his employer, and is far from being a popular person where he is known. Koreans consider the fly the personification of greed and shamelessness, for no matter how many times



FIG. 16.—Royal musician's hat. (No. 202,887.)



FIG. 17.—Royal servant's hat. (No. 202,882.)

the insect may be driven away from food, it will return to finish its meal. As the *shu re* seems to be solicitous only about his



FIG. 18.—House caps. (Nos. 202,881, 202,878.)



FIG. 19.—Banded house caps.

pecuniary remuneration, and cares nothing for reprimand or abuse, he receives no more consideration than a fly, and must wear on his head his badge of servitude, which resembles a fly's head.



FIG. 20.—General's helmet. (No. 201,436.)



FIG. 21.—Soldier's helmet. (No. 128,344.)

The hat of the royal musician (fig. 16), is shaped somewhat like the official hat, but having a higher crown, and tassels of red silk hanging from the sides and back. The projecting wings are square at the extremities. This style of head-gear is worn only by the royal band detailed to furnish music in the palace.

The hat of the royal servant is of buckram, covered with brown silk. It is most ingeniously folded flat, and when open assumes the oblique outline shown in figure 17. This hat is worn with a suit of the same color and a blue sash.

The Korean is never hatless. When in the house his head is covered with a gauze skull-cap (fig. 18), which is considered *en dëshabille*, only intimate friends seeing it worn, and to appear with



FIG. 22.—*a*, Swordsman's hat (No. 202,879). *b*, Soldier's and constable's hat (No. 77,058).

it on the street would be the height of impropriety. The house hats are sometimes made in veritable nests, one over the other (fig. 19), varying in height, and in all of them the topknot can easily be seen through the meshes of the hat.

All of these hats are composed of bands of horse-hair, of different heights, some wider at the top than at the bottom, some cylindrical, others square in shape and nearly all open at the top.

There are a number of military hats, indicating different branches of the service, as shown in figures 20–23. The general's helmet (fig. 20), is a very elaborate affair, ornamented with brass dragons,

phoenix, Sanscrit prayers for victory, red plume, and trident-shaped brass at apex. The soldier's helmet (fig. 21), is padded with cotton and stiffened with perpendicular bands of iron riveted through the cloth. Other military hats (fig. 22-23), are pot-shaped, visored, made of felt stiffened with buckram and ornamented with bright-red tassels and plumes of birds.

Hats appropriate to the season of the year are worn by different individuals, the gentleman's winter hood being an example in



FIG. 23.—Musketeer's hat. (No. 202,880.)

point (fig. 24). This is of brocade, lined with red woolen cloth and bordered with otter fur, and is one of the few instances in which woolen cloth is used in Korea for any purpose.

The ornamental hood, an example of which is shown in figure 25, is placed upon the head of a very young child, and for its "protection" various characters are embroidered in the ribbon. The black ribbon at the back of the cap is removed when the child becomes able to speak.

The hat cover, or *kano*, is worn to protect the national hat from rain. It consists of a polygonal cone of oiled paper, folding like an umbrella (fig. 26), and is secured to the hat by a string of white paper, crossed under the chin and held by the hand. When not



FIG. 24.—Gentleman's winter hood. (No. 77,080.)

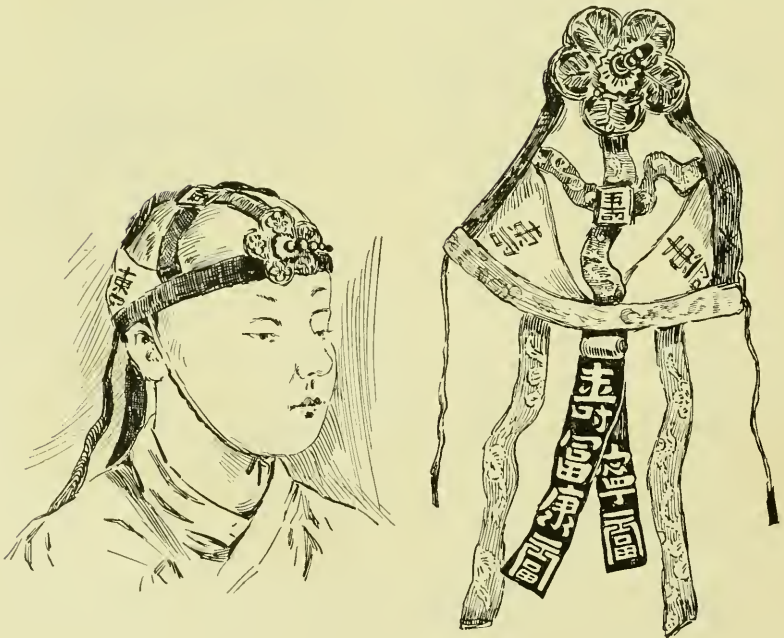


FIG. 25.—Baby's hat and detail of same. (No. 77,079.)



in use it is folded like a fan and carried in the sleeve. This is an interesting form of umbrella.

For the care of the hat, hat-boxes are used; these are woven of bamboo splints and covered with yellow oiled paper. An example is shown in figure 26.



FIG. 26.—Umbrella or hat cover (No. 77,019), and hat-box (No. 151,628).

Usually the women cover the face with their outer robe or dress, so that earlier writers about Korea affirm that the women wear no hats. In figure 27, *a*, is shown a small satin-covered cap, having an ornamental button of jade on top, worn by women of the official class. Figure *b* represents a similar hat in white for mourning,

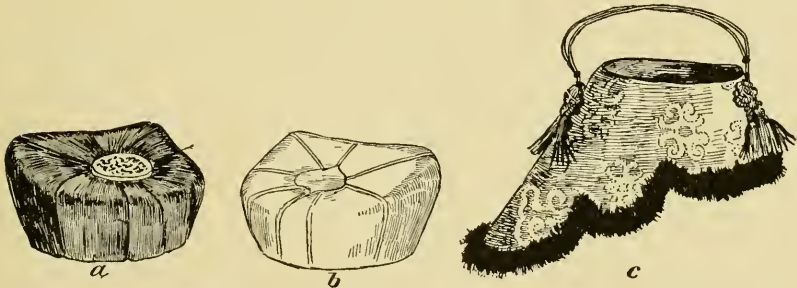


FIG. 27.—*a*, Lady's satin cap. *b*, Lady's mourning cap. *c*, Lady's winter hood.

and figure *c* is a winter hood of brocade, trimmed with fur and ornamented cords tied in fancy knots. In figure 28 are shown

methods of hair-dressing, and another style of hat with a streamer hanging down the back over the hair-knot, somewhat after the manner of the Tibetan woman.

As might be expected from the complexity of headdress, Koreans display the utmost skill in such manufactures. Nowhere in the world can better horsehair work be found, some of the hats showing as many as five different styles of hand-weaving so fine that only with a powerful lens can the stitches be seen.



FIG. 28.—Women's hats and mode of hair-dressing.

It is probable that the headband (fig. 3) is the oldest style of head-dress in Korea, and that the more complicated forms have been evolved during centuries of culture. Much of Korean custom is a survival of the influence of the Ming dynasty in China, whose culture was widespread in Korea.

There is one specimen in the National Museum which shows the Korean conception of a European hat. It has a high crown and is exquisitely made of horsehair and bamboo strips lacquered. It is an example of the revolutionary tendency of the reformers of 1895, and was one of the causes of the death and dispersion of those who would reform Korea in a year.

There are in all sixty-five different kinds of men's hats and about twelve different styles for children. Women are almost hatless, for they have only about half a dozen styles.

The people of Korea are rapidly adopting European ideas by introducing new laws, post offices, post roads, railroads, electrical plants, and many other improvements, and among the higher classes European dress has been adopted to some extent, yet changes of dress among the masses will come about but slowly, and it will be many years before the Korean hat will be relegated to the museum.

## THE HODGKINS FUND OF THE SMITHSONIAN INSTITUTION

BY HELEN WALDO BURNSIDE

In September, 1891, Mr. Thomas George Hodgkins, of Setauket, New York, after requesting and receiving information in regard to the aims and objects of the Smithsonian Institution, placed in the hands of the Secretary the sum of \$200,000, as a gift to the Institution, which was formally accepted at a specially called meeting of the Board of Regents, October 21, 1891.

Mr. Hodgkins stipulated that the income of \$100,000 of his gift should be devoted to the increase and diffusion of more exact knowledge in regard to the nature and properties of atmospheric air in connection with the welfare of man; it was not the donor's intention that the Fund should be limited to special investigation in sanitary science, but that the atmosphere should be considered in its very widest relationship to all branches of research. The income of the remaining \$100,000 was to be applied to the general purposes of the Institution.

Additional gifts were afterward received from Mr. Hodgkins, and, in finally closing the affairs of his estate, he made the Smithsonian Institution his residuary legatee, the general Hodgkins Fund being thus increased by a sum the exact amount of which is not yet definitely known.

In consulting with the Secretary and Assistant Secretary on the application of his gift, Mr. Hodgkins referred to the experiments of Franklin in atmospheric electricity, as an investigation germane to his foundation, and mentioned also the prize awarded by the French Academy of Sciences to Paul Bert for his discovery in regard to the influence of oxygen on the phenomena of vitality, expressing the hope that it might be thought advisable by the Institution to offer some very considerable prize which, by its magnitude, would call general attention to the subject in which he was so greatly interested.

With the intent of thus furthering the donor's wishes, the Hodgkins Prize Competition was announced in March, 1893, a prize of

ten thousand dollars being offered for a paper embodying some new and important discovery in regard to the nature and properties of atmospheric air, the Institution reserving the right to limit or to modify the conditions of this prize should it be found necessary.

A prize of two thousand dollars was offered for the most satisfactory essay on the properties of atmospheric air and the proper direction of future research in that connection, and a prize of one thousand dollars for the best popular treatise on atmospheric air.

The proposed establishment of the Hodgkins medal of the Smithsonian Institution was announced in connection with the prize competition, it being contemplated that this medal might be awarded annually, or biennially, for important contributions to the knowledge of the nature and properties of atmospheric air, or for practical applications of existing knowledge to the welfare of mankind.

The conditions governing the future award of grants to specialists engaged in original investigations of atmospheric air and its properties, were also announced, and many applications for such grants, as well as memoirs in competition for the prizes, were received close upon the general distribution of the circulars, which were issued in English, French, and German.

After an extension of time, decided on in the interest of all who might desire to submit papers, the competition was definitely closed December 31, 1894, two hundred and twenty-nine memoirs, which were eligible under the advertised conditions, having been received from competitors in the United States, France, Germany, England, Scotland, Ireland, Italy, Russia, Austria-Hungary, Norway, Denmark, Finland, Bohemia, Bavaria, Servia, Switzerland, Spain, India, Canada, Mexico, and Argentina.

In organizing the competition, a Committee on Award was appointed as follows: Doctor S. P. Langley, Secretary of the Institution, Chairman *ex officio*, Doctor G. Brown Goode, Assistant Secretary of the Institution, Assistant Surgeon-General J. S. Billings, U.S.A., and Professor M. W. Harrington, Chief of the United States Weather Bureau.

The Foreign Advisory Committee, as first constituted, was represented by Monsieur J. Janssen, Director of the Astrophysical Observatory of Meudon, Paris, Professor T. H. Huxley, F.R.S., and Professor von Helmholtz, President of the Physikalisch-Technische Reichsanstalt, Berlin. Subsequent to the death of Doctor von Helmholtz, Doctor W. von Bezold, Director of the Meteorological Institute at Berlin, was added to the advisory branch of the Committee.

After completing the examination of the papers submitted by the contestants, the committee awarded the first prize, \$10,000, to Lord Rayleigh of London, and Professor William Ramsay of University College, London, for the discovery of argon, a new element in the atmosphere.

The second prize, \$2,000, was not awarded, no contestant complying strictly with the terms of the offer.

The third prize, \$1,000, was awarded to Doctor Henry de Varigny, of Paris, for the best popular treatise on atmospheric air.

Honorable mention was made of twenty-one papers, for three of which a silver medal was awarded, and for six a bronze medal.

The gold medal of the Hodgkins Foundation, announced at the time of the competition as a future contingency, has been bestowed twice: First, April 3, 1899, on Professor James Dewar, F.R.S., of the Royal Institution, London, "in recognition of indefatigable researches, pursued for many years, which have been potent not only in increasing and diffusing a more exact knowledge in regard to the nature and properties of air, but have opened the way for the practical utilization of this knowledge in the advance of human welfare." Second, October 28, 1902, to Professor J. J. Thomson, F.R.S., of Trinity College, Cambridge, England, "in recognition of investigations on the conductivity of gases, especially on the gases that compose atmospheric air." (See plate L.)

A Hodgkins medal in silver, with a copy in bronze, has been presented to Pembroke College, University of Oxford, England, from which James Smithson, the Founder of the Institution, was graduated. These medals are placed in the library of Pembroke, forming an appropriate adjunct to the Smithsonian publications which are transmitted regularly to this establishment.

The prize memoirs, "Argon: A New Constituent in the Atmosphere," submitted in collaboration by Lord Rayleigh and Professor William Ramsay, and "Air and Life," by Doctor Henry de Varigny, as well as several other competitive papers, have been published by the Institution. Papers prepared by investigators working under grants from the Hodgkins Fund have also been issued, and others are in course of publication. Among them the following may be mentioned: "Composition of Expired Air, and its Effects upon Animal Life," by Doctors J. S. Billings, S. Weir Mitchell, and D. H. Bergey; "Atmospheric Actinometry," by E. Duclaux; "Atmosphere, Life and Health," by F. A. R. Russell; "Air of Towns," by J. B. Cohen; "Equipment and Work of an Aero-Physical Observatory," by A. McAdie; "Animal Resistance to Disease," and "Organic





HODGKINS MEDAL OF THE SMITHSONIAN INSTITUTION.



Matter in the Air," by D. H. Bergey; "Ratio of Specific Heats," by O. Lummer and E. Pringsheim; "Experiments with Ionized Air," and "Structure of the Nucleus," by Carl Barus.

A competitive memoir on life in high altitudes, which was submitted in Spanish by Doctors A. L. Herrera and D. Vergara Lope, of the City of Mexico, has been translated into French and published in that language by the authors under the title "La Vie sur les hauts Plateaux." The Institution has aided in the distribution of this work as recording valuable data relative to the influence of life in high altitudes, and especially concerning the treatment of tuberculosis by altitude. The book discusses also the acclimation of plants and animals to the conditions of high altitudes and, in general, subjects relating to the influence of atmosphere on human life and health. This memoir was one of those awarded a silver medal by the committee.

Frequent applications for grants are received, and notwithstanding the fact that limitations on the use of the Hodgkins Fund render it impossible to aid many promising and doubtless useful researches thus brought to the attention of the Institution, it has still been found practicable to further numerous investigations, some of which have proved noteworthy.

While the Fund is not limited in its application to questions of ventilation and sanitation, those subjects were among the first to receive attention. The reports, which have been published by the Institution, of Dr. J. S. Billings and Dr. S. Weir Mitchell, aided by Dr. D. H. Bergey, on their investigation to determine the nature of the peculiar substances of organic origin contained in the air expired by human beings, furnish practical results, the authors concluding that the problem of securing comfort and health in inhabited rooms depends on the consideration of the best methods of preventing or of disposing of dusts of various kinds, of properly regulating temperature and moisture, and of preventing the entrance of poisonous gases, like carbonic oxide, derived from heating and lighting apparatus, rather than upon simply diluting the air to a certain standard of proportion of carbonic acid present.

An early grant from the Fund was made to Doctors Lummer and Pringsheim, of the Physikalisch-Technische Reichsanstalt, Berlin, for research on the determination of the specific heat of gases, with a view of revising the value of the " $\gamma$ " constant. The results of this research were communicated, by permission, to the British Association for the Advancement of Science, and issued as one of the *Smithsonian Contributions to Knowledge* in a paper entitled

“A Determination of the Ratio of the Specific Heats at Constant Pressure and at Constant Volume, for Air, Oxygen, Carbon-Dioxide and Hydrogen.” Permission was also granted to issue a German edition of this memoir, and the investigation is to be further prosecuted under the direction of the Reichsanstalt.

An interesting research under a Hodgkins grant has been conducted by Mr. A. Lawrence Rotch, director of the Blue Hill Meteorological Observatory, at Hyde Park, Massachusetts, for experiments with automatic kites, to determine, by means of self-recording instruments, meteorological data in atmospheric strata inaccessible except by mechanical methods of exploring the atmosphere. The highest flight recorded during the experiments at Blue Hill up to July, 1900, was 15,807 feet, or but a trifle less than three miles, the kites carrying up with them meteorological instruments which recorded the elevation, the wind pressure, the dew point, and other facts of interest at the great altitude attained.

In addition to this investigation, in the spring and summer of 1899 Mr. Rotch conducted a short series of experiments in wireless telegraphy, in which kites were employed to raise the transmitting and receiving wires.

It may be noted that Mr. W. A. Eddy, who experimented with the aid of a small grant from the Hodgkins Fund, in 1894, at Bayonne, New Jersey, was the first to demonstrate the adaptability of a modern kite of his own device to the purposes of scientific investigation.

A research on the properties of air in connection with the propagation of sound, conducted by Professor A. G. Webster, of Clark University, has been aided by the Hodgkins Fund. An instrument invented by Professor Webster for use in this investigation gives the physical measure of a sound, not only when constant, but also when rapidly varying. It is expected that this research, which includes experiments on the propagation, reflection, and diffraction of sound, will furnish results of practical value in connection with the question of the acoustics of auditoriums.

Professor William Hallock, of Columbia University, New York, has been aided by the Fund in conducting a research having for its object the analysis of a particle of air under the influence of articulate sounds. This investigation, which has been conducted largely by means of instruments of Professor Hallock's invention, is expected to settle definitely the question of phase differences in the components of complex sound.

A Hodgkins research conducted by Doctor Louis Bevier, of

Rutgers College, has for its object the analysis of vowel sounds, detailed studies of the vowel series from *a* to *u* being in progress.

Professor W. C. Sabine, of Harvard University, who had charge of the design of the new Symphony Hall in Boston, and who has for several years given much attention to the problem of architectural acoustics, has also been aided by a grant from the Hodgkins Fund.

Professor Scripture, of Yale University, whose published researches relating to speech, or phonetics, have called attention to his special investigations, is now working under a Hodgkins grant on the construction of a machine designed "to play the vowels like an organ." Following the rule of the Institution, the application for a grant, in this instance as in others, was submitted to the highest accessible authority for an opinion before approval.

Mr. C. Canovetti of Brescia, Italy, a civil engineer who has been moderately aided by the Fund, has conducted a series of interesting experiments on air resistance, his reports having been accompanied by illustrations and numerical tables showing definitely the progress of his work.

The interesting researches on air currents conducted by Doctor Marey, of the Institute of France, have been recently furthered by aid from the Hodgkins Fund. An article on the history of chronophotography by Doctor Marey, which included a detailed description of his own experiments in this field, especially as applied to the motions of animals and to the movements of waves and currents of liquids which are invisible to the naked eye, was published in the Smithsonian Report for 1901. This investigation is expected to aid materially in the solution of various problems connected with the mechanics of propulsion in fluids, and at the same time to render service in solving practical questions in ventilation, etc.

The Hodgkins research of Doctor Victor Schumann, of Leipzig, on the emission and absorption of the gases of atmospheric air in the ultra-violet spectrum, is reported on in detail in the memoir now about to be published in the *Contributions to Knowledge*. The necessary apparatus for carrying on this difficult research has been designed by Doctor Schumann and constructed with his own hands, and the memoir detailing the course of the investigation contains an account of this special apparatus and the method of using it. So general has been the interest among specialists in this advanced investigation that permission was given to Doctor Schumann to publish without delay, in his own country, significant discoveries made in the course of his experiments.

A grant from the Hodgkins Fund to Professor Morris W. Travers, of University College, London, after the customary reference, examination, and discussion, was recently approved. This research deals largely with the liquid properties of hydrogen, and is reported on in detail in a memoir by Professor Travers, shortly to be issued by the Institution under the title, *Researches on the Attainment of Very Low Temperatures*.

Two memoirs, *Ionized Air* and *The Structure of the Nucleus*, by Doctor Carl Barus, who worked under the Hodgkins Fund, have recently been published by the Institution. On account of the immediate interest attaching to these investigations, Doctor Barus also was allowed to publish preliminary reports of his progress in the scientific journals. The investigation on the structure of nuclei is a continuation of the experiments with ionized air, and outstanding questions in the first memoir have been answered in the second. Both volumes appear among the *Contributions to Knowledge*. This research is interesting not only in its own methods and results, but because of its agreement with the data obtained by other investigators from different experiments and theoretically different points of view.

A recent grant on behalf of Mr. E. C. Huffaker is for the construction and practical application of a device intended to produce a uniform and measured flow of air through a tube of any desired diameter. This apparatus is primarily designed for use in connection with investigations in the line of biology, and it has already been applied to exact experiments in the development of the embryo of the egg. It is hoped that by means of this invention facts may be established which will prove of practical value.

Since 1899, *Terrestrial Magnetism and Atmospheric Electricity*, a journal of which Doctor L. A. Bauer is the editor, has been aided annually by a moderate grant from the Hodgkins Fund in the form of a subscription for a specified number of copies of the journal, to be sent out to specialists and educational establishments, as directed by the Institution.

While any general allotment of the income from the Hodgkins Fund for the purposes of investigation is precluded by the terms of the bequest, an application by an investigator who can comply with the conditions which, in accordance with the stipulations of the donor, necessarily govern the expenditures from the Fund, is sure of serious consideration.

## A NOTABLE SUCCESS IN THE BREEDING OF BLACK BEARS

By ARTHUR B. BAKER

It is well known to those familiar with collections of wild animals in zoological gardens and parks that bears in such places seldom produce young, and that to rear the cubs is still more unusual; so that it is generally conceded that the conditions incident to captivity almost preclude successful propagation. It is therefore worthy of notice that in a private park near Akron, Ohio, a pair of black bears has regularly bred and raised cubs during the last twelve years.

A little more than twenty years ago, Mr. R. H. Lodge established a picnic park along the shore of little "Silver Lake," at Cuyahoga Falls, near Akron, Ohio, operating it for several years by himself, and later with his son, Mr. W. R. Lodge. From the outset a small collection of North American animals was one of its features, and this was increased from time to time. In 1888 a pair of black bears was added. The female, captured on the north shore of Lake Superior, was received in July when about six months old, and a male of the same age was obtained shortly afterward from central Michigan. The two grew up together and when too old to be safely handled were placed in a brick pit built for their use. Here they have since lived (August, 1903), and that they have thriven during the fifteen years of captivity is apparent from the accompanying illustration (plate LI), which shows the two old bears and their three seven-months-old cubs.

The first cub was born toward the end of January, 1892, when the parents were four years old. The male was then seen at the entrance to the den with a dead cub in his mouth, but a prompt and careful examination of the premises failed to discover any others. With the exception of three years, when conditions were unfavorable, this pair of bears has since produced young each year, the record of births being as follows:

1892, January 23. One male cub, found dead.

1893, January 24. Two males and one female.

1894. No cubs born, owing to young of previous year having run with the mother throughout the summer.

- 1895, January 23. One male and one female.  
1896, January 24. Two males and one female.  
1897. One male (exact date of birth not noted, but between January 21 and 27).  
1898, January 24. One male and one female.  
1899, January 27. Three males.  
1900. No cubs born, as young of previous year had run with the mother during the summer.  
1901, January 26. Two males and one female.  
1902. No cubs born.  
1903, January 21. Two males and one female.

After the first litter, all of the cubs were raised, except five which met accidental death at ages varying from one to eight months.

The bears are kept in a circular brick pit 20 feet in diameter and 12 feet deep, built on the eastern slope of a hill where the ground is dry and there is good drainage. On the upper side, the top of the brick wall rises about three feet above the surface of the ground. The floor of the pit is of terra-cotta blocks set in cement and slopes toward the entrance gate, where drainage is provided by a gutter of the same materials. The brick-lined entrance passage, about 10 feet long and 6 feet high, is provided with inner and outer gates of iron grating and thus affords a chamber to separate the bears from the main pit when desirable. There is a water tank about 3 by 6 feet at one side of the pit. Two retiring dens are excavated in the bank, each about 5 by 6 feet and 4 feet high. These are 8 or 10 feet beneath the surface of the ground, are lined with brick and connected with the pit by a 24-inch circular opening. The entrance passage is provided with a similar but somewhat larger retiring den with a ventilating shaft in the top, while the only opening in the others is that leading to the pit. There is a supply of water, under pressure, within convenient reach, and the pit is frequently and thoroughly washed with a hose. When the retiring dens require to be cleaned, the bears are confined in the gateway passage.

The male bear is put with the female about the first of June and they mate in the latter part of June or the first week in July. They remain together in the pit until the time of hibernation. The cubs are born between the 21st and the 27th of January. Their presence in the den is at once made evident by their whimpering, which can easily be heard at the ventilator, but they are not seen till early in March. They are surprisingly small as compared with the size of the adult, for they weigh, at birth, only nine to twelve ounces.



THE FAMILY OF BEARS AT SILVER LAKE PARK.

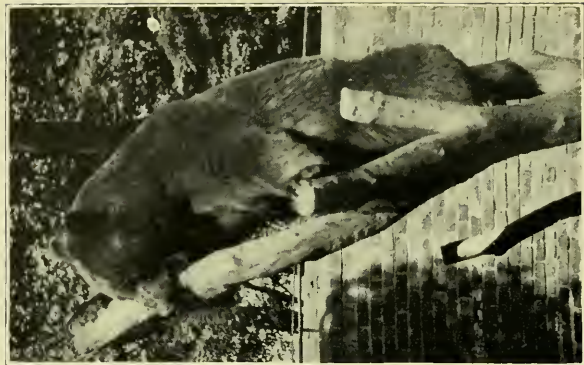








BLACK BEAR, TWELVE HOURS OLD; WEIGHT TWELVE OUNCES.  
(Springfield, Mass.)



THE FATHER OF THE AKRON  
FAMILY.

The eyes are closed and remain so for a month or more, and a little short, velvety hair on their bodies is the only indication of the heavy coat which they later acquire. (See plate LII.)

As the mother is likely not to breed while giving attention to the cubs, they usually are separated from her before the end of May, and thereafter are raised by hand. For the first few weeks their food consists entirely of milk; then they are gradually transferred to the mixed diet of the older bears. The cubs are vicious in their greediness and cannot be trusted to take their milk together; when only three and a half months old, one killed his brothers in a fight over a pan of milk.

The food given to the older bears is approximated as nearly as circumstances permit to that which they would obtain in the wild state. Scraps from the hotel and picnic tables furnish a considerable part of their fare during the summer, but throughout the season they are liberally supplied with such suitable green food as can be obtained. Dandelion tops, clover, and some other vegetables come with early spring and are followed by green corn, berries, and watermelons; and in the fall acorns are gathered for the bears. Green corn seems to be the favorite food and is consumed most largely in the fall, when the bears become very fat.

Accumulated fat and the approach of cold weather combine to dull the bears' interest in the outside world, so that they turn their attention to securing retreats for winter, for at the first severe weather each animal begins to make ready its den by dragging into it large quantities of dry leaves. They become more and more sluggish and about the middle of December withdraw to the dens for their long winter sleep. Usually they remain undisturbed until the beginning of March, when the first warm days bring them out to reconnoiter, and they soon afterward resume their interest in the activities of bear life.

The old bear is a model mother to the cubs as long as they remain under her care, even refusing on their account the attentions of her mate, but when they are taken away her affection for them seems soon to end. The two cubs of 1898 were removed in May and returned to the mother early in October, after first being kept for two weeks with only a grating between. She had seemed to recognize them, but when they were put together she at once caught the little male by the head and killed him, and only forcible measures prevented her from climbing the tree and repeating the operation on the other cub, which had taken refuge there. The father cannot be trusted at all with his offspring while they are very small. This

fact is recognized at Silver Lake Park and has been only too often proved in zoological collections elsewhere.

A number of the bears reared at Silver Lake have been sent to other parks, while some have been sold for meat. Several females were kept till they reached breeding age, at four years, and a second pit was built for them similar to the original one. They have produced a number of cubs.

The success of the Messrs. Lodge with their bears should not be attributed to any one feature of their management. The large amount and the character of the uncooked vegetable food used, probably have much to do with it, but the opportunity for isolated hibernation in snug, dry dens, and the manner of treating the mother and young, must have contributed largely to the result. The fact that there has not been a case of sickness among their bears, nor a death except through accident, is sufficient measure of their success.

It must not be inferred that bears have not bred in captivity elsewhere in the United States, for instances are well known, including the following: A grizzly bear in one zoological garden produced, in twelve litters, twenty-two cubs, but only one was reared. In another, twelve cubs out of thirteen died on the day of birth and one lived eleven days. Mr. W. T. Hornaday, Director of the New York Zoological Park, writes as follows regarding a birth in Prospect Park, Brooklyn: "In a den of about 20 by 30 feet, in which were five black bears, the oldest female gave birth to two cubs, and reared them. Her den was shallow, and its interior was badly exposed, but the mother persistently fought off all would-be intruders, and took good care of her young."

In Forest Park, at Springfield, Massachusetts, several cubs were born, one of which was reared. A black bear from the Yellowstone National Park, which was received at the National Zoological Park at Washington, on October 15, 1893, gave birth to two cubs on the 4th of the following February; one was accidentally killed by the mother the following day, while the other she reared to maturity. The weight at birth was nine ounces and the length eight and a half inches. The eyes were first opened on the thirty-ninth day.

Hibernation in captivity appears to be more unusual than breeding, though several instances of this have been noted, and one, given by Mr. W. T. Hornaday, is especially interesting. The bear in question was at Mandan, North Dakota. He was kept on a long chain in a vacant lot, and on the advent of severe weather dug a hole about five feet deep in the open prairie, going down at an angle

of about 45 degrees. He retired into this hole on December 14 and did not reappear until March 17 of the following year.

In closing this brief account, acknowledgment is made of the courtesy of Messrs. R. H. and W. R. Lodge in giving information and furnishing photographs, also of attentions received from them during a visit to Silver Lake Park. It is hoped that a knowledge of their methods in caring for bears may be of service to others who have these animals in their charge.



Black bear, four months old,  
Springfield, Mass.

## CHINESE MEDICINE

BY JAMES M. FLINT

The Chinese trace the origin of medicine to an emperor named Shen-nung, who is said to have reigned about 2700 B. C. He first experimented on the medicinal qualities of herbs and their application in the treatment of disease, and to him are ascribed the earliest writings on the subject. The principal one of his medical works is entitled *Shen-nung Pen ts'ao king*. The statements in regard to the origin of this work, both as to authorship and to time, are exceedingly doubtful, the probability being that its precepts were traditional until, after a long period, they became incorporated in the writings of a more modern author. It can hardly be doubted, however, that a system of medical practice was established in China long before any now known to have existed among western nations.

Concerning the theories of disease held by the Chinese, and the rationale of their modes of treatment, the information at hand is indefinite and perplexing. According to Cleyer,<sup>1</sup> their theory of disease is based on the existence of two radical principles, *Yin* and *Yang*, translated as "heat" and "moisture," which give life and movement to all things. Health depends on the maintenance of an exact balance of these two elementary principles, any disturbance of the proper relations between them producing all the phenomena of disease. Others interpret *Yin* and *Yang* to be two principles or powers in nature, male and female, ever active in producing the physical, chemical, and vital phenomena which appear within and round us. When these principles are equalized there is repose or a state of health. If the male principle is in the ascendant there is disease and it is inflammatory; if the female principle predominates the disease is of a typhoid character.

In addition to the rationalistic theories of disease and its treatment, superstitious and religious notions concerning them prevail very widely. Magical rites and charms occupy a large place in both preventive and remedial medicine, and temples devoted to the worship of medical divinities are numerous and much frequented.

<sup>1</sup> *Specimen Medicinæ Sinicæ*.

In these temples are images representing eminent physicians of history and tradition who have been deified and to whom worship is paid. In particular there are ten celebrated doctors of special sanctity often referred to, but no two lists of their names are exactly the same. It would seem that some of these divinities have lists of numbered prescriptions, and by means of correspondingly numbered bamboo sticks the patient draws by lot the prescription suited to his disease.

In the examination of a patient the Chinese doctor determines the diagnosis, prognosis, and indications for treatment chiefly from the condition of the pulse, the appearance of the tongue, and the facial aspect. For medical convenience the human body is divided into three regions: (1) the superior region, from the head to the epigastrium; (2) the middle region, from the epigastrium to the umbilicus; (3) the inferior region, from the umbilicus to and including the pelvis. For each of these regions there is a distinct pulse which may be felt at different positions along the radial artery at the wrist, about half an inch apart. These pulses mark the condition of certain organs in the different regions according as they are felt on the right or the left arm. Thus the superior pulse on the right arm marks the state of the heart; on the left arm, of the lungs. The middle right pulse indicates the condition of the stomach and spleen, the middle left pulse the state of the liver. The lower right pulse is controlled by the right kidney and large intestine; the lower left by the left kidney and small intestine. The delicate variations in quality, force, and rhythm of these pulses which the Chinese doctor claims to detect are not evident to the ruder touch of the foreigner.

Examination of the bodies of the dead never having been allowed or practised, the knowledge of anatomy is necessarily crude. A general idea of the internal organs of the body, and their location, has been forced upon them by the accidents of war and peace, but for the rest imagination has supplied the place of demonstration. A theory of a double circulation is held, by means of which the "spirits," which are the vehicle of the radical principle *Yin* (heat, or the male principle), and the blood, which conveys the *Yang* (moisture, or the female principle), are distributed throughout the body. This circulation begins in the lungs at three o'clock in the morning and completes its round in twenty-four hours. For the accommodation of this circulation they count twelve principal canals—six passing from above downward, and six from below upward.

There are also accessory canals or vessels, eight of which run transversely and fifteen obliquely.

The materia medica of the Chinese is extensive and is used with prodigality by both the sick and the well. The classical authority for the use of drugs is a sort of dispensatory called *Pen-ts 'ao kang-mu*—"A Synopsis of Ancient Herbals,"—compiled by one Li-Shi-Chen in the latter part of the sixteenth century. The last reprint of this work was in 1826, and it appears in forty-three quarto volumes, the first three containing over 1100 rude wood-cuts of the minerals, plants, and animals treated of in the body of the work. Drugs are classified in three kingdoms and fifteen divisions, as follows: (A) Inanimate substances—water, fire, earth, metals, and stones. (B) Plants—herbs, grains, vegetables, fruits, trees. (C) Animals—insects, scaly animals, shelly animals, birds, quadrupeds, man. Comprised in these divisions, and described in the *Pen-ts 'ao*, are 1892 distinct drugs. These, in various combinations, are presented for use in about ten thousand formulæ. All drugs are considered as having certain inherent qualities of heat, cold, warmth, or coolness, and these are noted. But in spite of the mystical and utterly unintelligible explanations of their actions given by Chinese authors, it is probable that medicines are administered, in China as elsewhere, principally as specifics, that is to say, "good" for the disease.







MAP OF GODHAVN PROVINCE, NORTH GREENLAND, BY R. HAMMER AND K. I. V. STENSTRUP, 1878-80.  
 (Meddelelser om Grønland, vol. iv, pt. II, 1893.)

# NOTES ON THE ROCKS OF NUGSUAKS PENINSULA AND ITS ENVIRONS, GREENLAND

By W. C. PHALEN

## PART I

### INTRODUCTION

The rocks which prompted the following study were collected by Messrs. Chas. Schuchert and David White on Nugsuaks peninsula and its environ, Umanak island, during the summer of 1897. It will be recalled<sup>1</sup> that the object of the excursion of the above named gentlemen was primarily paleontological and stratigraphical, and not petrographical, hence the field relations of the rocks were not worked out with the detail demanded by the student of petrography. When it is understood, moreover, that but twenty-three days were at the disposal of these travelers for the pursuit of the legitimate object of their trip, it will be evident that but little time could be devoted to side issues.

"Nugsuaks peninsula . . . lies somewhat obliquely between  $69^{\circ} 55'$  and  $70^{\circ} 57'$  north. From the nearest point between Karajaks fjord and Torsukatak glacier at its base to the western extremity is about 90 miles, the width for nearly two-thirds of its extent being 30 miles. The Cretaceous and Tertiary deposits constitute the western two-thirds of the peninsula, the Tertiary sediments continuing to near its western extremity. The interior of the peninsula is either covered by local ice caps or is unexplored, so that, with the exception of Ifsorisok, an inland point near the western end of the peninsula, the Cretaceous and Tertiary have been seen only beneath the basalt along the coast or along two short river valleys."<sup>2</sup> For all practical purposes Umanak island may be considered a portion of this peninsula, and, geologically speaking, continuous with the mainland lying to the south; hence its sedimentaries, if such exist, must be of lower Cretaceous age, belonging to the Kome series. It is a very small body of land, lying directly northeast of Kook, the point where the Greenland expedition landed,

<sup>1</sup> See *Bulletin Geol. Soc. Amer.*, IX, p. 344, 1897-98.

<sup>2</sup> *Ibid.*, p. 345.

and judging from the character of the material submitted for study, its surface rocks are in a remarkably perfect state of preservation, as compared with those collected from the mainland. Why this should be so is rather difficult to say off-hand, though it seems most plausible to assign it to recent glacial scouring, the island being a typical nunatak. A short distance west of Kook glacier, on the mainland of Nugsuaks peninsula, the Kome plant beds are described<sup>1</sup> as overlying probable older beds, lying between gneissoid hillocks. These gneissoid terrains are assumed by me to be Archean and of undoubted continuation with that gneiss, to be directly described, which constitutes the entire southern portion of Umanak island, stretching back from the coast in low-lying irregular masses for a mile or so.

#### UMANAK ISLAND

*Gneiss* (Cat. No. 75,478).—This rock is typically gneissoid in character, consisting of roughly alternating layers of quartz, associated with feldspar and biotite. At times these layers may be traced completely through an ordinary hand specimen. At other times they pinch out, or merge into each other, forming broad bands of dark and light colored constituents. These are bounded by slightly narrower bands of pure quartz and feldspar. This latter constituent is apparently fresh. It is light pink in color and may be readily recognized by its numerous glistening faces from the base and brachypinacoid. The quartz may be readily recognized by its glassy appearance and lack of cleavage. The micaceous constituent is perfectly black; in spots, where alteration has occurred, it is golden brown. Withal the specimen appears as though it might have come from a zone far within the crust of the earth, instead of from its surface, as is the case.

When viewed in thin section, the structure is typically hypauto-morphic granular, consisting of an irregular mosaic of the constituents already noted with feldspar as the most abundant mineral. Excepting an occasional microcline, the feldspar is nearly all orthoclase and albite. It frequently exhibits perthitic intergrowths, the interlamination, at times, being exceedingly fine. Slight alteration has resulted in the usual products, kaolin and sericite. These occupy, at times, the entire grain; again occurring in irregular lines or patches or simply scattered along cleavage lines or the bounding planes of twinning lamellæ. When in the last position, the included particles are frequently oriented normal to the bounding planes.

<sup>1</sup> Op. cit., p. 346.

Even with the highest powers of the instrument, the determination of the exact nature of these inclusions is unsatisfactory. The most that may be said is that they are exceedingly irregular, often continuous and skeleton-like in shape. Of a dull brown color, they must be composed essentially of iron oxide and are undoubtedly the basis of the pink color of the feldspar.

Such inclusions are often observed in the quartz, though when present in this mineral, they are confined generally to the cracks which seam this constituent. They have probably reached their present position through capillary action, having originated in the adjoining feldspathic minerals. Besides orthoclase, albite, and microcline, there is still a fourth feldspar, which reveals a faint suggestion of albite twinning. Owing to the imperfect development of the twinning, and its extreme rarity, absolute measurements of its extinction were well nigh impossible. Such as were made are very small and the feldspar is undoubtedly the acid plagioclase, oligoclase. The feldspars show a few inclusions of apatite, zircon, and sphene, and at times rather large quartz grains. Rarely these latter show a tendency toward micrographic development.

Quartz is present in abundance, but only in its ordinary form. The only colored constituent is biotite. It occurs in irregular scales, never automorphic, rounded against the quartz and feldspar. At times it is deep green in color, but more usually deep brown. The greenish tints are peripheral and may be due to alteration. With the biotite is associated much secondary magnetite, often in skeleton crystals, often occurring in seams, and at times replacing its parent mineral. Inclusions in the biotite could not readily be detected, owing to the opacity of this mineral. Titanite, which is a notable accessory, is frequently associated with the magnetite. Zircon and apatite, which occur in small amounts, have already been mentioned. To summarize, then, there are present albite, orthoclase, microcline, oligoclase, quartz, biotite, kaolin, sericite, apatite, zircon, and sphene.

An analysis of the rock follows:

ANALYSIS OF GNEISS. (W. C. PHALEN, ANALYST.)

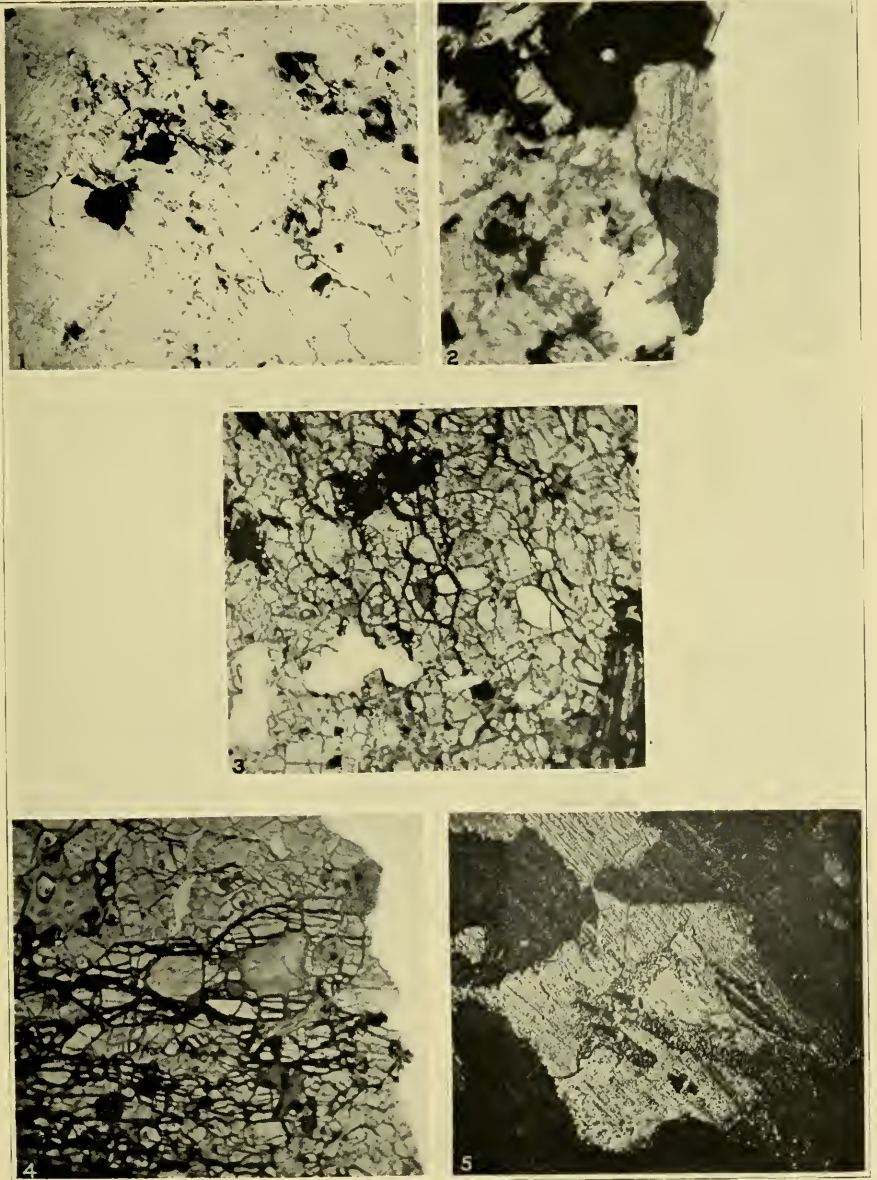
SiO <sub>2</sub> .....	69.07
Al <sub>2</sub> O <sub>3</sub> .....	14.09
Fe <sub>2</sub> O <sub>3</sub> .....	1.49
FeO .....	2.37
MgO .....	.98
CaO .....	3.14
Na <sub>2</sub> O .....	5.18
K <sub>2</sub> O .....	2.71
H <sub>2</sub> O above 100° .....	.26

H <sub>2</sub> O below 100° .....	.04
TiO <sub>2</sub> .....	.78
P <sub>2</sub> O <sub>5</sub> .....	Trace
MnO .....	Trace
	100.11

*Granite*.—Associated with the gneiss occurs a rock without banding, a normal granite (Cat. No. 75,479). It is probably of similar genetic origin to the gneiss. Its mineralogical constituents are the duplicates of those in the gneiss, even to the merest accessories and alteration products, but the proportions vary, especially that of the micaceous mineral, biotite. Its geological relationships, further than that it constitutes a part of the lower portion of the island, as with the preceding rock, are unknown. It is of medium grain, of pinkish hue, and though a surface sample there are no evidences of alteration visible to the naked eye, with the possible exception of an occasional green speck of chlorite, which may be a product of biotitic alteration. The structure is hypautomorphic granular.

Under the lens the feldspar is seen to constitute fully seventy-five percent of the rock, the four varieties mentioned with the gneiss being present, viz., orthoclase, albite, microcline, and oligoclase. There is also an excellent development of the micrographic structure. The feldspars have slightly changed, producing kaolin and sericite, and contain many liquid inclusions, as is also the case with the quartz. Strongly pleochroic biotite, slightly altered and frequently surrounded by a rim of secondary skeleton magnetite, primary magnetite, zircon with small portions of epidote, chlorite, and apatite, constitute the remaining constituents of the rock. A unique association of original magnetite and zircon was noted as shown indistinctly in plate LIV, 1. The zircon forms a nearly complete ring about the magnetite, its *c* axis occupying a tangential position with respect to the periphery of the enclosed mineral.

Directly back of this low lying expanse, which has been described as stretching a mile back from the coast, there rises to a height of 3,700 feet, a typical nunatak, composed of granite (Cat. No. 75,480), essentially similar to that just described. This forms the main residual mass of the granite intrusion, and it is fairly probable that the more basic gneiss already described is simply a differentiated portion of this central magma. Thus it agrees beautifully, so far as position goes, with our usual conceptions of magmatic segregation which places the acid phases in the center of an eruptive mass and the more basic phases in the periphery. The difference in elevation of the granite masses is perhaps due to a fault. That



PHOTOMICROGRAPHS OF GREENLAND ROCKS.





dislocations have occurred in certain portions of the elevated mass is evident from the foldings exhibited in the dark intercalated layers in the granite. These horizontal dikes of diorite, for such they prove to be, present many phases, as present in the Museum collection, ranging from the finest grain in the lowest to a pegmatitic facies. In every case the structure is decidedly schistose, traceable to the shearing action consequent to earth movements.

An analysis of this granite follows:

ANALYSIS OF GRANITE. (W. C. PHALEN, ANALYST.)

SiO <sub>2</sub> .....	76.03
Al <sub>2</sub> O <sub>3</sub> .....	12.02
Fe <sub>2</sub> O <sub>3</sub> .....	.69
FeO .....	.68
MgO .....	.18
CaO .....	1.61
Na <sub>2</sub> O .....	2.97
K <sub>2</sub> O .....	5.72
H <sub>2</sub> O .....	.20
TiO <sub>2</sub> .....	.28
	100.38

The granite needs no detailed description, agreeing so far as constituents go with the granites previously described. Like these, it contains the four feldspars, orthoclase, microcline, albite, and oligoclase. The albite frequently exhibits perthetic intergrowths with both the potash feldspars. Granophyric groups were also noted.

*Diorite.*—This rock (Cat. No. 75,481), constituting the lower dark zone in the central elevated mass of the island, might on casual inspection be called amphibole schist, for it has a decidedly laminated structure, produced by a similar orientation of its two essential components, amphibole and feldspar (for such the lighter mineral proves to be). The amphibole occurs in elongated, lath-shaped forms with glistening cleavage plates and is perfectly fresh. Associated with it in a very few places occurs a greenish mineral, probably chlorite, though no such mineral was observed in the thin sections studied.

In spots the crystallization of the amphibole is much coarser than the average. Here it is associated with feldspar, also of coarser grain, producing a pegmatitic facies. An occasional grain of pyrite was observed on the fresh fracture, and an occasional garnet also was noted.

Under the microscope the amphibole proves to be the light green variety, hornblende. It occurs in continuous masses, with splendid

development of the prismatic cleavages. The pleochroism is very strong with *A*, yellow, *B*, yellowish-green, and *C*, bluish-green. The absorption scheme is the usual  $C > B > A$ . Very few basal sections were observed, but when noted, the rather rarely developed macropinacoidal cleavage (100) was distinctly seen. An occasional twin was noted, and with the exception of an occasional apatite, a fragment of feldspar, and perhaps a zircon or two, the hornblende contains no included minerals. The feldspar, the light colored mineral filling the interstices between the hornblende, has undergone considerable change. In polarized light it appears rather clouded, though not at all commensurate with the amount of change which it has undergone. The true extent of this change may be seen by diminishing the illumination; then it appears that alteration is quite general, that as a rule it follows the cleavage cracks or composition planes of the twins, and that, as a result, a secondary mineral has been produced with brilliant interference tints, probably sericite. To a very small extent calcite is present in spots, as proved by faint effervescence when the specimen is touched with acid. Twinning of the plagioclase, according to the albite law, was noted, though it is not general, and the high symmetrical extinctions indicate, together with those on the pinacoids, that the feldspar is a labradorite of a composition approximating  $Ab_1An_1$  to  $Ab_5An_5$ . It is evident that the feldspar has accommodated itself to the space remaining after the crystallization of the ferromagnesian constituent, and in the complete absence of quartz was the last constituent to crystallize.

Additional to the feldspar and hornblende occurs magnetite, most commonly situated on the peripheral portions of, or enclosed by, the hornblende. Usually it is surrounded by a colorless or light-green rim, appearing as though formed at the expense of the amphibole. An occasional red scale of hematite was also observed, associated with the magnetite. Pyrite, already noted among the megascopic constituents, is readily diagnosed in incident light. Tabulated in the order of their abundance, there are present:

As Essentials	{	Hornblende.	{	Sericite.
		Labradorite		Calcite.
As Accessories	{	Magnetite.		
		Pyrite.		
		Hematite.		
		Zircon.		
		Apatite.		
		Garnet.		

The upper intercalated dikes (Cat. Nos. 75,482, 75,483, 75,484) are as a rule more coarsely grained than the lowermost, but in most instances the decided schistose structure is still apparent. In addition to the minerals mentioned in the description of the lowermost dike, biotite is developed macroscopically, and is especially prominent in the most coarsely grained phases of the rock. There is present also a silvery, micaceous mineral, evidently a secondary product after amphibole and biotite. When viewed in thin section, the minerals appear pronouncedly coarse in grain and irregularly segregated. At times whole areas of variously oriented amphiboles occur with no feldspar whatever; while masses of feldspar with no foreign minerals occur in the same way. The pleochroism of this amphibole is similar to that of the hornblende already described, namely, *A*, yellow with greenish tinge; *B*, green with a yellow cast, and *C*, blue or bluish-green. The absorption scheme is  $B \cong C > A$ . Generally the mineral appears to be quite fresh; it, however, shows bright interference tints at its edges, as compared with those of its mass. This is due to incipient alteration which has produced a light brown micaceous mineral, strongly dichroic, and with bright interference tints, as already noted. In some cases much of the unaltered hornblende still remains.

The development of the feldspars reaches its largest scale, of course, in the pegmatitic facies, and here could be observed albite twinning in the macroscopic way. Here, however, the feldspar could be determined only unsatisfactorily in the ground mass of the rock, alteration having proceeded too far to admit of positive measurement. A fresh cleavage fragment from one of the pegmatite areas gave extinctions of oligoclase. This is too acid, however, to agree with the main mass of the feldspar, which, as in the case of the lower dike, is made up chiefly of andesite-labradorite or a plagioclase of intermediate composition. Sections which might ordinarily have served as diagnostic material are completely transformed into brightly polarizing scales, leaving, but not always, a tiny spot, still showing the albite lamellæ intact.

Additional to the minerals already described, quartz and biotite occur in the pegmatitic facies of this rock. The latter mineral is best developed in the coarser portions, but it occurs also in the main ground mass, in the usual lath-shaped forms with fringed terminations, and also in scales from the base. In ordinary light it is brown in hue; in polarized light, strongly dichroic with rays of a brownish tint, vibrating normal to its cleavage, while those parallel to this direction are so strongly absorbed as effectually to obscure all color.

Magnetite occurs rather plentifully, especially in the region of the altered mica. It has been produced as an alteration product of the ferro-magnesian minerals and simultaneously with the secondary mica. Some original magnetite was also noted.

The lower dike material, with its finer grain and homogeneous structure, represents perhaps more fairly than do any of the upper sheets the typical dioritic magma, whence the sheets have come. Its homogeneity renders it a safer criterion to judge of the constitution of the dioritic magma—hence its analysis is given, as follows:

ANALYSIS OF DIORITE. (W. C. PHALEN, ANALYST.)

SiO <sub>2</sub> .....	47.80
Al <sub>2</sub> O <sub>3</sub> .....	18.24
Fe <sub>2</sub> O <sub>3</sub> .....	.35
FeO .....	9.27
MgO .....	8.08
CaO .....	11.44
Na <sub>2</sub> O .....	2.24
K <sub>2</sub> O .....	.45
H <sub>2</sub> O above 100° .....	.58
H <sub>2</sub> O below 100° .....	—
TiO <sub>2</sub> .....	1.46
P <sub>2</sub> O <sub>5</sub> .....	.24
MnO .....	.55
	100.70

In addition to the rocks already described from Umanak island, there occur others of sufficient interest to warrant description. Unfortunately the relationships of these rocks are entirely unknown, hence their value as petrographic factors in this province is largely curtailed. The one is a syenite, the other a diorite of more than passing interest, owing to the occurrence in it of an amphibole with peculiar parting. The description of these rocks with an analysis of the separated amphibole follows.

*Syenite*.—This rock (Cat. No. 75,485) is salmon pink in color, with holo-crystalline texture, consisting for the greater part of feldspar with an occasional vitreous quartz. The structure tends to the porphyritic, the largest feldspars frequently having diameters of one centimeter or more and sinking from this size to microscopic dimensions. Occupying fissures between the feldspathic particles may be seen a green mineral, closely resembling epidote in color, while lustrous specks of pyrite are not uncommon. Cavities are scattered throughout the mass of the rock.

The texture is typically hypautomorphic granular, with porphyritic structure, and when viewed through the microscope presents a most heterogeneous appearance. This heterogeneity is in complete accord with the macroscopic appearance of the rock, for in places it is essentially syenitic, in other spots granitoid. Areas devoid of quartz are contiguous to those where silica constitutes fully one-fourth the mass.

This silica does not have the appearance of typical original quartz; it does not form distinct crystals, but appears in vein-like masses, elongated and irregularly shaped, surrounding large and distinct microclines, and frequently enclosing smaller particles of the same mineral. In this occurrence it is distinctly pœcilitic. It has evidently, at least in part, in these spots been produced as a result of changes which the feldspar has undergone. To strengthen this hypothesis, similar irregular masses, very much smaller than those above referred to, occur in the midst of the larger feldspars.

In addition to the secondary quartz, there is also present a smaller portion of undoubted original quartz. This occurs with automorphic outlines in sections from the prism zone with pyramidal terminations and in various other irregular forms. Liquid inclusions are abundant.

Feldspar, of the variety microcline, constitutes the largest mass of the rock. It is associated with a small amount of orthoclase. In the former mineral a splendid development of the characteristic grating structure obtains. This constituent, as well as the orthoclase, is universally filled with minute scales or lenticular particles of iron oxide, at times segregated so as comparatively to obscure the mass of the rock. These particles give, even in the thin sections, a faint reddish-brown tinge to the rock and are the basis of the salmon pink color observed in the hand specimen. These inclusions are frequently massed, especially at the boundaries of the crystals and in those portions of the rock where crystallization has taken place on a fine scale, *i. e.*, in the non-porphyritic portions. In the phenocrysts they are scattered in irregular and broken lines and are accompanied by a multitude of liquid inclusions. No perithitic intergrowths were noted.

Of accessories there are very few; epidote and zircon were noted. The former, of undoubted secondary origin, occurs in very irregular patches, frequently elongated. It is faintly pleochroic and is much obscured by segregated iron oxide. Basal cleavage is roughly developed. A scattering zircon was noted, but of apatite there is apparently none. Allusion has already been made to the abundance

of iron oxide, hydrous and anhydrous, which constitute the pigment in the rock.

*Diorite* (Cat. No. 75,486).—As with the diorites already described (see p. 187), so here also is the orientation of the essential constituents, hornblende and feldspar, such as to produce a decided sheared or schistose structure. Besides these two constituents, an occasional speck of light brownish-gray silvery mica may be seen, usually included in the hornblende.

*Hornblende*.—This mineral is present in irregular and connected grains, strongly pleochroic, with vibrations of the following color scheme: *C*, generally, bluish-green; *B*, green, and *A*, yellow with absorption  $B > C > A$ , with *B* and *C* lying very close together. Of inclusions, few were noted, an occasional irregularly shaped magnetite, a fragment of feldspar, and an occasional speck of brown mica, constituting the list.

Upon closer examination the hornblende presents many points of rather unusual interest. Its color has been described as green; this statement, however, needs qualification, for in spots the mineral is perfectly colorless, other amphibolic characteristics remaining in full perfection. This bleaching of the mass of the crystal is apparently not connected with decomposition or alteration in any way. The cleavage lines of the mineral stand out full and clear. The extinction angles remain as in the contiguous green portions and the mineral extinguishes as a unit. The interference tints of the bleached portion are higher than those of the green parts. A bleaching, similar to this, has been remarked by G. H. Williams<sup>1</sup> in the hornblende of cortlandite. This author says: "The mineral (hornblende) becomes colorless and consequently non-pleochroic, while retaining the compact structure and optical behavior of the unaltered portion; later there is developed, particularly around the edges of the hornblende, a bright, emerald green substance which, on account of its lack of dichroism and feeble action on polarized light, may be regarded as chlorite." The hornblende of this specimen also exhibits a uniform bleaching in its peripheral portions, and the hornblende has doubtless become chlorite in these places. Very often the spaces, or boundaries between adjacent hornblendes, are filled with sericitic material which has come from the feldspars. It is possible that the waters which have produced this sericitic change may have bleached the hornblende along its path, thereby changing its composition to the less ferruginous chlorite.

<sup>1</sup> *Am. Jour. Sci.*, xxxi, 1886, p. 34.

Another feature of the hornblende is a perfect parting parallel to the plane (101). This is rather indistinctly shown in plate LIV, 2, in the right portion of the figure, and in the same crystal of hornblende there is shown the dark hornblende associated with the bleached material. This parting is far more perfect than any cleavage possessed by amphibole, not excepting the prismatic. It is present as a series of rather fine, sharp black lines, parallel to each other, and making an angle of  $75.8^\circ$  with the prismatic cleavage on the brachypinacoid. Though rather rare, the phenomenon is not unique; it is first mentioned by Jermejew,<sup>1</sup> and incidentally referred to by Williams<sup>2</sup> and Vom Rath.<sup>3</sup> Cross<sup>4</sup> and Mügge<sup>5</sup> have also remarked it.

In more recent articles, Williams<sup>6</sup> and Weidmann<sup>7</sup> have described the phenomenon at some length, and have noted in connection with it twinning lamellæ. At times in the sections under discussion a faint white band could be seen between the parting planes. The highest powers, however, failed to resolve any twinning lamellæ, and it is probable that none exists in these particular sections. Though it cannot be positively stated that the parting planes are concentrated near fractures and are hence of dynamic origin,<sup>8</sup> the evidence which points to this view is very strong. As a rule they are concentrated at the boundaries of the hornblende crystals and tend to pinch out toward their centers. If now it is borne in mind that the rock under discussion has been sheared, and that its present crystalline nature is most evidently the result of dynamic metamorphism, it will not be difficult to assign a similar explanation for the observed parting planes. An analysis of the separated amphibole is as follows:

SiO <sub>2</sub> .....	42.79
Al <sub>2</sub> O <sub>3</sub> .....	15.04
Fe <sub>2</sub> O <sub>3</sub> .....	5.44
FeO .....	11.61

<sup>1</sup> *Neues Jahrbuch f. Min.*, etc., 1872, p. 405.

<sup>2</sup> *Am. Jour. Sci.* (3), XXIX, 1885, p. 486.

<sup>3</sup> *Sitzungsber. d. Niederrh. Ges. f. Natur. u. Heilkunde*, July 7, 1886

<sup>4</sup> *Tschermaks Min. u. Pet. Mitth.*, IV, p. 386, 1881.

<sup>5</sup> *Neues Jahrbuch f. Min.*, etc., 1889, I, 243.

<sup>6</sup> *Am. Jour. Sci.*, XXXIX, 1890, p. 352.

<sup>7</sup> *Am. Jour. Sci.* (4), XV, March, 1903, p. 229.

<sup>8</sup> Williams (*Am. Jour. Sci.*, XXXIX, May, 1890, p. 335) and Weidmann (*ibid.* (4), XV, March, 1903, p. 230) both assign a secondary, dynamic action as the cause of these gliding planes.

MgO .....	11.00
CaO .....	10.24
Na <sub>2</sub> O .....	2.89
K <sub>2</sub> O .....	.47
MnO .....	.54
	100.02

The feldspar of the rock is much kaolinized and clouded in spots. As a result of this, many tiny flakes of a highly doubly refracting mineral are present. This mineral, sericite, often penetrates the bounding planes between the hornblendes and frequently the larger cracks in the latter mineral. This process of sericitization is peculiar in that its effects are local, *i. e.*, one section of a feldspar may be completely changed, while the contiguous crystal may not have suffered any alteration whatever. Albite twinning, sometimes accompanied by pericline twinning, is frequent, though not the rule. The small extinctions, symmetrical with respect to the traces of the albite lamellæ, indicate a feldspar of the andesine series.

Occasionally there occurs as inclusions in the hornblende and in the feldspar a fibrous mineral, evidently a member of the mica group. Its exact nature, further than this, cannot be ascertained, owing to the paucity of strong diagnostic features. It is yellow in color, strongly dichroic, with rays vibrating parallel to the cleavage planes of a yellow tint and colorless normal to this direction. The hornblende, near at hand, has been bleached, and the yellowish-brown color of the mineral in question naturally leads to the supposition that part of the iron content of the hornblende has been appropriated. It forms an intermediate link between the muscovite, which is present in slight amount, and the bleached peripheral parts of the hornblende.

One other constituent deserves mention, *i. e.*, magnetite present as inclusions in both hornblende and feldspar. It is irregular in shape and is frequently surrounded by a pale halo.

#### NUGSUAKS PENINSULA

*Kaersut.*—Returning now to the mainland of Nugsuaks peninsula at Kook and traveling west to Kaersut, the gneissoid crystallines still continue overlain by cretaceous shales and sandstones, intercalated with coal streaks and basalt flows. At an altitude of 880 feet above the plant beds the shales have been baked and the lignite converted to carbonite by the intrusion of a mass of horizontally bedded peridotite which forms a cliff 200 feet high.



*Peridotite var. picrite*

At first glance this peridotite (Cat. No. 75,487) might be mistaken for a basalt, with an interlacing network of segregated olivine. It is black in spots, or rather has a blackish-brown augitic base, through which the olivine runs in zigzag courses, producing a mottled or inlaid appearance, remarkably clear and striking. A vein-like penetration of olivine into the black ground mass was also observed. On closer examination the grain of the rock proves to be rather fine, the olivine granules, however, being macroscopically distinct, while those of the ground mass are practically irresolvable.

Under the microscope the following minerals were observed—olivine, augite, chlorite, feldspar, biotite, magnetite, limonite, hematite, and apatite. Of these constituents olivine is by far the most abundant. It occurs in perfectly automorphic forms, excepting when corroded by the surrounding magma. The crystals are in large part isolated and distinct from each other. Often very irregular masses are present. When isolated, there is, as a general rule, a development of the micropœcilitic structure, though in no case are the isolated particles broken from a parent crystal, but are *per se* crystalline units. In many instances the olivines present a completely shattered aspect. Fissures penetrate them in all directions, often arranged radially with respect to the center and generally filled with a light-brown ferritic pigment. This phenomenon is not attributable to any pressure which the rock has sustained, for no evidences of strain are visible in any of the sections studied. Only in a single instance was undulatory extinction noted. Not only are the individual phenocrysts shattered, but the entire sections themselves seem to be rifted in a more or less regular manner. Along these zones of fracture the rock is broken up into a series of parallel cracks, filled as with the olivines with brown and black iron oxides. We have here a phenomenon closely related to rifting, a microscopic phase of jointing, as it were.

In many instances the olivines are in an advanced state of alteration and often the entire nucleal portions of crystals have been converted into light green, slightly dichroic prochlorite. This chloritization furnishes the key to the explanation of the radiating cracks observed in the olivine, for the process is essentially one of hydration and expansion, which produces the radial cracks observed.<sup>1</sup> The process is not always nucleal, however, for simultaneous with and independent of these changes in the interior of the crystal,

<sup>1</sup> See plate LIV, 3, in the automorphic olivine, represented in the middle of the illustration.

similar changes have occurred in the peripheral portions. Accompanying the separation of prochlorite there is much light-brown iron oxide, limonitic matter, resulting from the ferruginous portions of the olivine. Often these ferritic portions are oriented in fairly parallel layers about the prochlorite nuclei. Immediately adjacent occurs a layer of limonite, bounded in turn by a rim of serpentine, while this in turn is surrounded by a border or zone of magnetite, compact and black with jagged border, the points projecting normal to the surfaces of alteration. At times the limonite is absent; in other cases limonite alone is present with no magnetite.

Alteration is not at all confined to the olivine, for whole areas of pyroxene have made way for it and, curiously enough, in those spots where the changes in the pyroxene has been most profound, the olivine retains its original perfection of form and composition.

Liquid inclusions are abundant and are arranged in zones or clouds, nearly always concentrically and in juxtaposition to a layer of iron ochre. Often these inclusions are so numerous as to cause these particular areas to become nearly opaque.

The ground mass of the rock is formed by a violet-tinted augite, faintly green, however, in spots. It is not pleochroic. Sections from the two pinacoids are well represented. The augite, like the olivine, exhibits the micropœcilitic structure, with a particularly interesting development represented in the accompanying plate LIV, 4, to the right. It will be noted that there are two automorphic olivines adjacent; that to the left has its interior filled with augite, optically continuous with that which partially surrounds it. That the olivine formed first is assured; that the augite filtered in after the formation of the olivine was complete forces the assumption of a primary cavity in the olivine. It seems to the writer that the phenomenon is an excellent illustration of the power of crystallization even under the most adverse circumstances, the olivine assuming its perfect form, even in spite of the intimate admixture of foreign augite molecules; that with the formation of the olivine phenocrysts the augite molecules were thrust apart to the interior and here segregated, optically continuous, however, with the main augitic mass without. The phenomenon is unique, only this instance having been observed in the sections studied in this series. In spite of this, I have dwelt at some length upon it with the hope that my explanation might be the means of bringing to light a more plausible solution of the phenomenon.

The iron oxides occur in the usual forms of magnetite, hematite, and limonite, included in the olivine, augite, chlorite, etc. Most

abundantly in the prochlorite occur magnetite and hematite, without definite form, appearing in irregular scales, sometimes occupying entire centers of chlorite masses, at other times arranged peripherally in tiny elongated and jagged masses, normal to and in contact with altering olivine surfaces, as already noted under that mineral. Iron ore is also included in the chlorite, resulting from pyroxenic alteration. What appears to be iron ore is also relatively abundant in both the radial and parallel systems of cracks. That it is not mica is proved by its non-pleochroic character and from the fact that it is almost universally confined to the ferromagnesian constituents, ending abruptly at their junctions with the plagioclase. In color it is light reddish-brown, and this ends its resemblance to the small amount of biotite occurring in the rock. It is filled with flakes of black iron oxide, which seem to have resulted from it, and is without doubt limonite, partially changed in spots to magnetite and hematite.

The remaining constituents of the rock are biotite, feldspar, apatite, with small amounts of chromite and pleonaste. The biotite is dichroic in dark and light shades of brown, the latter tint becoming very nearly colorless. Owing to the trifling amount of feldspar present, enough satisfactory measurements could not be made to judge of its exact composition with any degree of assurance. It exhibits albite twinning wherever it occurs, but symmetrical extinctions were more difficult to obtain. The highest equal extinctions were  $25.5^\circ$ , indicating a feldspar of composition approximating  $Ab_1An_1$ .

Apatite occurs in relatively large amounts in the usual form of long, slender prisms in radiating aggregates. A small amount of chromite with a trifling amount of pleonaste were also detected by chemical means.

An analysis of the pyroxene follows:

SiO <sub>2</sub> .....	49.49
Al <sub>2</sub> O <sub>3</sub> .....	5.45
Fe <sub>2</sub> O <sub>3</sub> .....	1.04
FeO .....	3.39
MgO.....	15.88
CaO .....	24.07
Na <sub>2</sub> O .....	.82
MnO .....	.18
	<hr/>
	100.32
Sp. Gr. ....	2.890 ✓

*Basalt (Bearing Native Iron)*

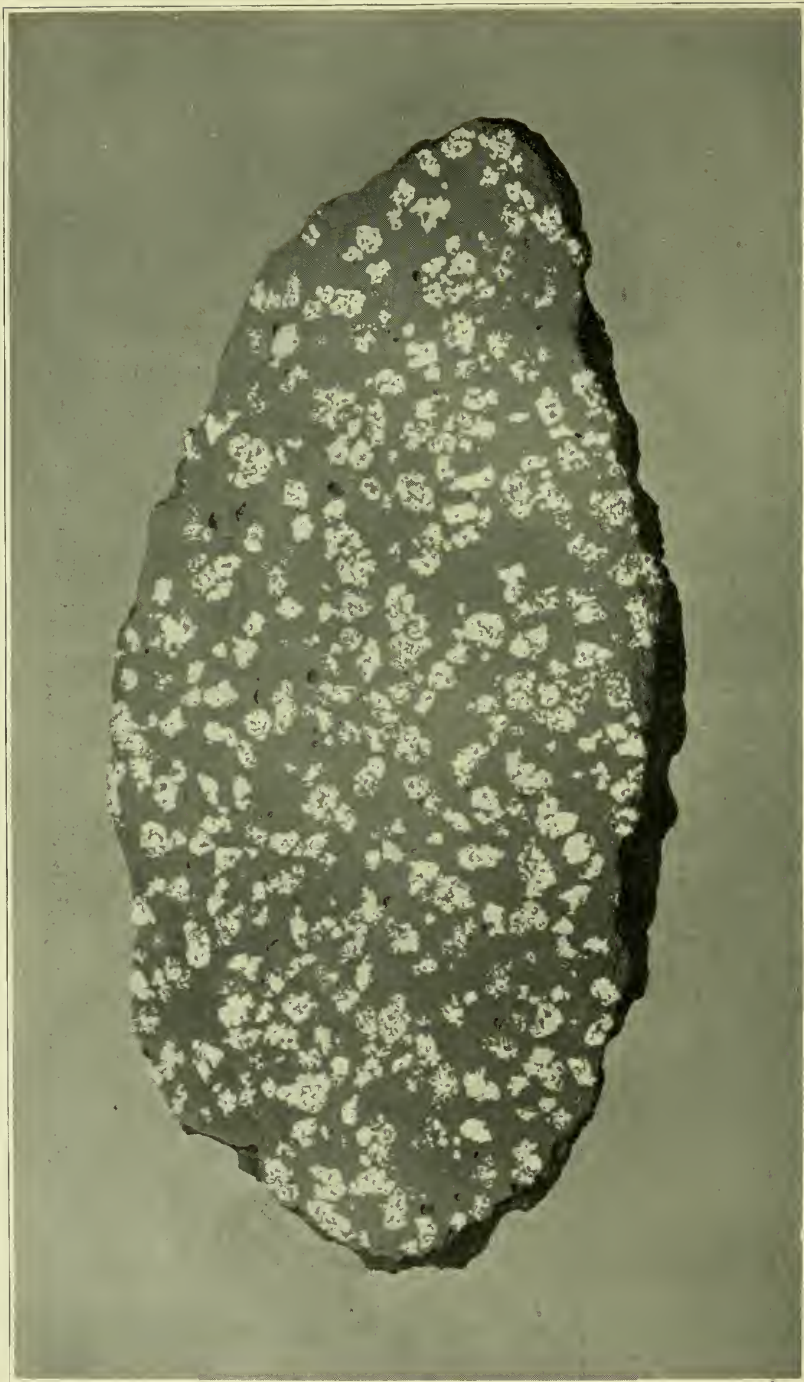
In addition to the occurrence of basalt in sheets, conformable with the bedding, the basalt of the region about Kaersut cuts the sedimentaries in dikes. Much of this basalt is decomposed, that with original vesicular structure (Cat. No. 75,495) having its cavities filled with zeolitic material and secondary quartz. Of peculiar interest among the basalts is the occurrence at Kaersut of the far-famed iron-bearing rock. Its occurrence at this particular point, so far as the writer is aware, has not been reported before, though its occurrence in the immediate vicinity has been described, as at Blaaufjeld (Ovifak), Mellemfjord, Asuk, Arveprindsen's Eiland, Niakornak, Fortune's Bay, Fiskernaes, Ekaluit, etc., where the rock has been collected and of which analyses have been made.<sup>1</sup>

From a petrographic point of view this is by far the most interesting of all the specimens brought from Greenland, and so far as the writer is aware is the only rock of undoubted terrestrial origin known which carries native iron in any considerable amount. It resembles closely an aërosiderolite, stony iron, and for many years was supposed to be of extraterrestrial origin.<sup>2</sup> Its very close resemblance to certain members of the meteorite family will be noted from the accompanying illustration, plate LV. The specimen (Cat. No. 53,479) now in the petrographic collection of the U. S. National Museum was, before cutting and polishing, roughly ellipsoidal in shape, with a major axis of 17 cm. and a minor axis of 9 cm. When cut, polished, and etched with nitric acid (sp. gr. 1.42, dil. 1:10) the variation in size and structure of the metallic blebs was beautifully developed. It will be observed that the inclusions are of most irregular shapes and sizes, ranging from 1.5 cm. in greatest dimension down to mere points. They often surround patches of the basaltic ground mass, and frequently several blebs of minute size colonize and closely simulate typical graphic structure, with, however, the regular outlines of the inclusions lacking. It is quite probable that such patches represent cross-sections of the ramifications of a single enclosed mass. While studying the thin sections of the basalt, it was observed that these metallic segregations were not at all as homogeneous as they appeared after remaining on exhibition for some years. It was plainly evident that at least two different kinds of iron are present, a black variety and a lighter variety with a silvery sheen. The irons are very irregular in outline. On etching

<sup>1</sup> Chemical Researches on the Metallic Iron from Greenland, by J. Lorenzen, 1882, *Meddelelser om Gronland*, IV, pt. II, 1893, p. 135.

<sup>2</sup> Nordenskjöld in *Geol. Mag.*, IX, 1872, pp. 88, 461.





BASALT WITH NATIVE IRON, KAERSUT, NUGSAKS PENINSULA, GREENLAND. (No. 53479, U. S. N. M.)

this composite nature is plainly exhibited and may be seen in detail in the accompanying illustration (plate LIV, 5). Macroscopically the two irons appear to be mixed promiscuously, and it is impossible to say with any degree of assurance which is the older, assuming that there is a difference in age. On etching, as has been remarked, the structure of these metallic inclusions is beautifully developed. The duality in composition is accentuated and a damascene luster becomes apparent. It must not be inferred, however, that the individual light and dark patches of a given bleb are quadrilateral, for they may be and are of almost any shape whatever. They may best be described as rudely polygonal, with stippled surfaces and sharply contrasted by virtue of their light and dark shades as noted above. Though former writers, Nordensjöld,<sup>1</sup> Rink,<sup>2</sup> and Steenstrup,<sup>3</sup> claim to have observed Widmanstätten figures in some irons, others have been found which do not show such markings. In the specimen at hand, there is no regular orientation of surface markings, the parallel elongated grooves having been produced during the polishing.

It has been remarked that two different irons are present. In the absence of a separation and chemical examination, such a statement needs qualification. From the physical point of view, this is true. A chemical examination may, however, reveal similarity in composition—in this case, the marked difference in structure then might be explained as a peculiar phase of isomerism, viewed from the standpoint of the ultimate chemical molecules, and from the physical side the differences presented may be assigned to peculiarities in the orientation of the physical as contrasted with the chemical molecules. The solution of this problem, however, lies beyond the scope of a petrographical discussion and belongs to the sphere of the metallographer.

In thin section the basaltic portion of this rock is seen to be composed almost entirely of pyroxene and plagioclase feldspar with abundant albite twinning. Of these two components pyroxene is by far the more abundant. It is perfectly colorless and stands out, in virtue of its strong relief, from the accompanying weakly refracting feldspar. It occurs in small irregular patches among the lath-shaped feldspar microlites. Then it occurs in larger, irregular masses, usually elongated and in forms approaching rectangles. When in

<sup>1</sup> *Geol. Magazine*, IX, 1872, pp. 88, 461.

<sup>2</sup> *Oversigt over Kgl. Danske Videnskabernes Selskabs Forhandl.*, 1854, p. 1.

<sup>3</sup> On the Presence of Nickel-iron with Widmanstätten Figures in the Basalt of North Greenland, K. J. V. Steenstrup, 1882, *Meddelelser om Gronland*, IV, pt. II, 1893, p. 115.

basal sections, it is observed that prism faces are poorly developed as compared with the pinacoids. There are traces of a rude and irregular parting parallel to these latter surfaces.

In spots it is partially altered with the separation of yellow and black iron oxides, the former hydrous. Along the cracks chlorite is slightly developed. Twinning with the twinning plane (100) was observed in several instances. The pyroxene is closely related to the augite group. With the feldspar it is often enclosed in the metallic portions.

The feldspar of the basalt is in two generations. The crystals of the first separation often attain a length of 3 mm., the microlites often sinking to ultra-microscopic dimensions. At times the larger feldspars exhibit undulatory extinction; they were undoubtedly subjected to strain during the closing stages of magmatic consolidation. The feldspar is in a perfect state of preservation, colored occasionally by the presence of hydrous iron oxide, especially in the immediate region of the iron inclusions. Its high symmetrical extinction lying between  $35^{\circ}$  and  $40^{\circ}$  indicates a feldspar of the composition  $Ab_3An_4$ . It is, therefore, a feldspar of the labradorite-bytownite group.

Magnetite (and this is the only remaining constituent noted in any considerable amount) is relatively abundant. It occurs in irregular elongated forms, often approaching a dendritic development, but the typical skeleton-like development was not seen. It is especially abundant in the region of the native iron, and here a rude fluxion structure of the entire basaltic portion of the rock was noted.<sup>1</sup>

The remaining basalts, collected from the vicinity of Kaersut, are of the usual olivine and non-olivine varieties, much decomposed and presenting nothing of unusual interest. Their detailed description will, therefore, be omitted.

Lying loose, just back of Kaersut, occurs a peculiar rock (Cat. No. 75,488) which deserves more than passing notice. It is brownish-red in color on the fresh fracture and is traversed by tiny veinlets of calcite; this latter mineral, however, is not confined to particular strips, the rock effervescing in all parts on the application of acid. Although of a coarsely crystalline character, with the exception of an occasional rather large irregular patch of tarnished olivine, the character of the ground mass cannot be made out with ease. The olivines, for the greater part, glisten in reflected light, and present a

<sup>1</sup> For a very complete bibliography on the iron-bearing basalt of Greenland, see Dr. Th. Nicolau, *Meddelelser om Gronland*, xxiv, 1901, p. 217, and for a brief résumé on the work done on the nickeliferous iron in the basalt of Greenland, see *Gisement et Nature du fer nickelifère du Gronland*, by F. Johnstrup, published in *Meddelelser om Gronland*, iv, pt. II, 1893, p. 270.



brown surface, not characteristic at all. Evidently the olivine has decomposed along its cleavage planes. In spots, the clear green and rough surface of the mineral appear.

The minerals, in their order of abundance, are olivine, feldspar, pyroxene, iron ore, serpentine, calcite, and apatite. These are combined in a hypautomorphic, holocrystalline mass with olivine, the first mineral of the consolidation. This constituent is by far the most abundant, occurring in irregular masses, with the usual hexagonal forms. It is usually much shattered and fractured, due to disintegration, which is far advanced in some of the crystals, and which is accompanied by a copious deposit of iron ore in various stages of hydration which has segregated along the cracks.

In some of the olivines there is present what might be called at first sight a pseudo-cleavage—very fine straight lines or spaces, for the greater part normal to the pinacoidal cleavage, but often parallel to this cleavage. With the highest powers of the instrument this is seen to be due to lenticular masses of iron oxide, rather scattered in the body of the crystals, but becoming more abundant near the main cleavage cracks and finally disappearing in a pleochroic pigment present in such cracks. Liquid inclusions are very abundant.

After olivine had crystallized out, the next mineral to appear was pyroxene. It occurs in irregular masses of light green color, with prismatic cleavages well developed. Extinctions range as high as  $44^\circ$ , indicating an augite of intermediate alumina and iron content. It is extremely abundant and shows no decomposition whatever.

Magnetite, with other iron oxides, occurs in several forms in the rock, inclosed in the ferro-magnesian constituents, rarely or never in the feldspars. It is part original and part secondary, resulting from the olivine. The original crystals are in the form of cubes and octahedrons, sometimes twinned. Then there occur skeleton crystals of the most wonderful patterns, as described by many petrographers and figured by Pirsson<sup>1</sup> and Hobbs.<sup>2</sup>

Magnetite occurs as an alteration product after olivine, often clouding and rendering opaque whole phenocrysts of this mineral. Patches of olivine are also rendered partially opaque by separated red hydrous iron oxide.

After these constituents, olivine, augite, and original magnetite, had separated, the feldspar accommodated itself to the residual space. It is remarkably fresh and, for the greater part, free from inclusions. It occurs in lath-shaped forms twinned according to the Carlsbad

<sup>1</sup> *Twentieth Ann. Rep. U. S. G. S.*, pt. III, 1898-99, plate LXXI.

<sup>2</sup> *Twenty-first Ann. Rep. U. S. G. S.*, 1900, pt. III, p. 65.

and albite laws. The extinctions, according to the statistical method, range as high as  $31.5^\circ$ , which would place the feldspar in the class intermediate between those of the formulæ  $Ab_1An_1$  and  $Ab_3An_4$ . The composition may then be represented by the formula  $Ab_7An_8$  and it would be classed among the labradorites.

The remaining constituents are serpentine, calcite, and apatite. Serpentine occurs as an alteration product of the olivine, appearing in cracks with a fibrous structure, with fibers normal to the altering surface. It shows aggregate polarization tints of dull gray, often becoming bright yellow. Apatite occurs in automorphic elongated prisms, enclosed in the olivine and feldspar. Calcite is also present.

A partial analysis of this rock, together with a discussion of its name and place in the new quantitative classification of igneous rocks<sup>1</sup> will be found in Pt. II, p. 211, of this article.

#### UJARARTORSUAK

Westward from Kaersut, the Cretaceous rocks are seen resting unconformably upon a bluish-green, highly altered basalt. A little to the west, the beds exposed in the sea-cliffs are dislocated for several hundred feet by a fault, directly beyond which the strata are cut by three dikes, the two westerly of which are parallel with the bedding in places. These intrusive basalts are believed to be of Tertiary age. The dikes are apparently of the same rock as the intrusive sheets themselves and probably represent the vents through which the sheeted material has reached the surface. Both olivine and non-olivine varieties are represented in the Museum collection, and from the similarity in composition and general features, the detailed description of but one will be attempted, that from an interbedded conformable sheet at Slibstenfjeld, directly back of Ujarartorsuak.

*Basalt.*—This basalt (Cat. No. 75,489) is greenish-gray in color and breaks with a roughly conchoidal fracture. In the greenish-gray fine-grained ground mass occasional specks of yellowish-red iron oxide are evident to the naked eye, as also are much larger automorphic crystals of a light-colored and well-cleaved mineral, presumably feldspar. Examined with the hand lens, though not salient, it is very abundant in lath-shaped forms. The rock presents a decomposed appearance, and the acid test reveals the presence of much calcium carbonate.

In thin section the rock appears holocrystalline, xenomorphic with lath-shaped feldspars, pyroxene, magnetite, hydrous iron ore, calcite,

<sup>1</sup> *Quantitative Classification of Igneous Rocks*, by Cross, Iddings, Pirsson, and Washington. Chicago, 1903.

etc. In places it shows undulatory extinction. It appears to be decomposed in spots throughout; the ferromagnesian constituents have completely changed and the feldspar has suffered locally in the same way, while in places the latter mineral is remarkably fresh and determinations of its character may be made with ease. The positions of the pyroxene and olivine, if the latter mineral were ever present, are now occupied by green and brown pigments. Magnetite, of course, is always present.

The constituents may be described as follows: Feldspar, the most abundant of the components still preserved in fresh condition, shows abundant albite and Carlsbad twinning. Symmetrical extinctions on the trace of the clino-pinacoid (010) range as high as  $35.6^\circ$ . The Michel-Levy method of Carlsbad and albite twins corresponds to a plagioclase of the composition  $Ab_3An_4$ , which is borne out by the high symmetrical extinction given above. Thus the plagioclase may be termed a labradorite bytownite and is very basic in composition.

In spots this feldspar is much kaolinized; it is cracked and secondary calcite has filtered into or formed in the fissures, filling them completely. Flakes of the greenish pigment to be subsequently described are also present, as well as elongated, lenticular, and lath-shaped forms of the same coloring substance. In general these inclusions are without regular orientation, but in the vicinity of and along the composition planes, there is a parallelism evident. At times cloud-like masses, elongated normal to the *C* axis, were detected with the number 7 objective. Magnetite, though an inclusion, is not abundant in the plagioclase. Its form is not automorphic, and part, even here, may be secondary.

The residual mass of the rock is largely a conglomerate of decomposition products, of which the most abundant are iron ore, calcite, chlorite, and serpentine, and much material, isotropic and secondary, whose properties are not at all diagnostic. These minerals are scattered promiscuously throughout the rock, in contact with and overlying each other. If we assume that the calcite areas represent original pyroxene and the serpentine is taken as a rough index of former olivine, then the original rock consisted of pyroxene, feldspar, olivine, magnetite, and apatite, in the order given.

From the intervening localities, at which explorations were conducted, namely Saviarkat, Kookanguertunek, and Niakornat on the north side of the peninsula, and Ata and Patoot on the south side, nothing of petrographic interest was obtained, owing to the very advanced state of decomposition of the rocks at these places. At

Alianaitunguak, however, lying to the west of Ata, olivine basalt was collected in a fairly good state of preservation. At Atanekerd-luk, on the southeastern coast, some specimens were collected, among them olivine gabbros and monzonite, the former constituting the main mass of the small peninsula. The only representation of this large areal extent is a single hand specimen (Cat. No. 75,490), somewhat decomposed, but still well enough preserved to admit of satisfactory examination. In color it is old rose, spotted here and there with what appears to be a secondary mineral, but which on examination in thin section proves to be a surprisingly fresh pyroxene. Sometimes this green mineral forms a continuous network in the red feldspar. It is this latter constituent which forms the bulk of the rock and from which nearly all the secondary constituents have been derived. Among these latter, calcite is readily distinguished, occurring in tiny anhedrons throughout the red plagioclase ground mass.

Viewed in thin section the rock presents a hypautomorphic granular appearance. Among the most abundant minerals is pyroxene. It is light brownish in hue, approaching at times a violet. Prismatic sections, both 100 and 010, were observed, the latter giving extinctions as high as  $52.9^\circ$ . These sections are naturally most numerous, but octagonal basal sections showing both prismatic cleavages were surprisingly well developed. Twins of the usual variety, the twinning plane being the orthopinacoid (100) were noted. With the lowest powers of the instrument the augite appears perfectly fresh. Even the highest powers prove that decomposition has not advanced very far. Even those parts of this mineral which project into thoroughly decomposed parts of the rock, consisting mainly of viridite, are plainly discernible, their crystalline outlines showing with much distinctness. Naturally in such areas the augite is much decomposed, but the evidence is plain that the greenish residual product is not *chiefly* derived from the augite. Along its cleavage planes foreign matter has filtered in, while a portion of such material has been produced *in situ*. Inclusions of hydrous iron ore and magnetite are present. Thus, to summarize, we may say that, although the augite has slightly altered, alteration has taken place only at vulnerable points and it is yet the most perfectly preserved of the constituents. In age it is older than the feldspar.

Though augite presents the same appearance throughout its entire extent, so far as progress in alteration is concerned, the same is not true of the plagioclase. Though perfectly fresh in spots, it presents all phases of alteration to the fully kaolinized material. It exhibits a

splendid basal parting in many of its lath-shaped forms, and the process of alteration has begun along these planes of weakness, but not always, for peripheral alteration has advanced to such a degree that it must have been at least simultaneous with, if not antecedent to, the changes along the basal partings. This alteration has filled the space originally occupied by the feldspar with a greenish substance, which, for want of a better term, I have referred to as viridite. In part this viridite is very dark bottle green, changing through various greenish and yellow shades to a bright saffron yellow. Undoubtedly much of the pigment of the viridite is iron oxide in various stages of hydration. In plain polarized light and with the very highest powers these pigments seem to be made up of shapeless patches of brownish-yellow material with occasional specks of magnetite and lath-shaped particles, all identical with that observed in the basal partings of the plagioclase.

Needles of apatite are abundantly scattered throughout, while underlying the heterogeneous mass may be observed the faint grayish-blue interference tints of the feldspar. Hence it is plain that these decomposition products owe their origin to the feldspar chiefly and not to the augite. We also have in these abundant products a ready explanation of the brilliant reddish hue of the plagioclase observed in the hand specimen.

In spite of its almost completely altered condition in places, the feldspar at times is even fresher than the augitic constituent. This is the exception, however, and not the rule. It is fortunate, however, in that it enables the feldspathic minerals to be diagnosed with no difficulty whatever. Its extinctions range in the neighborhood of  $25^\circ$ , the maximum symmetrical extinctions obtained being  $26.3^\circ$ . The feldspar, then, is a typical labradorite of composition  $Ab_1An_1$ .

Of the accessory constituents, olivine was noted in a few sections in an advanced state of change. It appeared with its usual complement of cracks, filled with dark-brown ferruginous matter. Cavities are rather numerous; in many instances their outlines are suggestive of the former presence of olivine. Even were olivine present to this extent, it would still be classed as a minor accessory.

Iron ore is present in considerable quantity. It is confined to the decomposed portions of the rock almost exclusively and is very irregular in outline. Although present in large masses, it appears to be at least in part secondary. Much of this dark opaque mineral is pleonaste. Chlorite is present in small quantity, bordering the augite. Calcite, in tiny anhedrons, also occurs as a decomposition product. Apatite has already been referred to.

In summary we have then as original constituents, labradorite, augite, magnetite, pleonaste, apatite, biotite, and olivine; as secondary constituents, hydrous iron oxide, chlorite and perhaps a small amount of serpentine. Of these original constituents the labradorite and augite only rank as essentials, the remaining constituents are accessory. The rock, therefore, may be classed as an olivine gabbro.

*Quartz Monzonite.*—This rock (Cat. No. 75,491), of which a single specimen was secured, is light gray in color with a ground mass composed of feldspar with semi-lustrous cleavage plates. Scattered through this white ground mass lie elongated crystals of a black mineral, hornblende. In some places, locally segregated, occur bunches of mica flakes. Drusy cavities are quite frequent. An occasional pellucid quartz was also noted, but though macroscopically evident, it is a very minor constituent.

Though apparently fresh, the rock, a surface sample, has undergone considerable alteration and weathering, and the feldspars are considerably kaolinized, presenting under the microscope grayish-brown cloud-like masses, which, however, give the dull-gray interference tints.

In texture the rock is panautomorphic; all the grains are crystalline, approximately the same size, approaching automorphic forms, yet few or none possessing them.

In thin section the appearance of the rock duplicates its megascopic features. By far the most abundant constituent is feldspar. This has decomposed to such an extent that in some spots identification is impossible, and even when freshest its identification is obscured from the large quantity of separated material, which makes the cleavage lines most indistinct. This separated material is, for the most part, kaolin. It is brownish in color and is made up of flakes and needles without any action on polarized light. It is scattered in translucent clouds throughout the mass of the feldspar. This latter mineral gives in some sections parallel extinctions; in others, the angles range from  $8^{\circ}$  to  $18^{\circ}$ ; such sections evidently approach the clinopinacoid and show an elongation of the feldspar parallel to the *c* axis. Though generally untwinned, in places albite lamellæ were noted. These small extinctions point to the presence of albite and oligoclase. In some spots, in the neighborhood of larger quartzes, a micropegmatitic development of quartz and oligoclase was seen. Carlsbad twinning was also noted.

Additional to these acid feldspars, another group of plagioclases is present of a much more basic character. These basic feldspars are twinned both according to the albite and Carlsbad laws, hence

advantage could be taken of Michel-Levy's method on sections normal to 010. Extinctions in one part of the Carlsbad twins range as high as  $31^\circ$ , in the other part  $15.5^\circ$  is the observed angle. Evidently the feldspar is entirely different in composition from those already observed and should be classed as a labradorite with composition very close to  $Ab_3An_4$ . The basic labradorite is not nearly so abundant as the more acid substance.

Associated with the feldspars are the following minerals: Amphibole, pyroxene, zircon, quartz, apatite, and magnetite, besides some hydrous iron ore. Of these minerals amphibole is by far the most important and most interesting, owing to its variety. It occurs in at least three different types, ordinary hornblende of deep chestnut-brown color, a light green phase, while a third variety has been derived from the pyroxene with which it is now associated. Of these forms the ordinary variety hornblende is most common. It is strongly pleochroic, the rays vibrating parallel to *C* being a deep chestnut-brown, those parallel to *B* of a similar but lighter shade, while those parallel to *A* are yellowish-green. The absorption scheme is the usual  $C > B > A$ , but the difference between *B* and *C* is very slight.

The hornblende is generally lath-shaped with jagged or frayed terminations. Sections parallel to 100 and 010 are present. No crystallographic terminations were noted, but basal sections (001) are frequent with prism and clinopinacoidal faces well developed, the macropinacoidal showing as a rule. The secondary hornblende is light chestnut-brown in color. It is generally associated with the unaltered portions of the original pyroxene, whence it has been derived, and crystals of light-brown pyroxene were noted with extinctions as high as  $45^\circ$ , whose edges and corners had completely gone over to hornblende of a markedly darker hue, with extinctions ranging in the neighborhood of  $20^\circ$ .

The third form of amphibole is usually associated with the dark and light brown varieties already described. It occupies in every instance a peripheral position and sometimes has a fibrous radiating structure—though as a rule the structure of the associated hornblende is repeated in the green mineral. Most commonly, its form is that of the amphibole, *i. e.*, lath-shaped, or rather it forms a part of the lath-shaped crystals. Cleavage in its prism zone is well developed. Its pleochroism, bluish-green in the prism zone, with yellowish-green hues normal to this direction, together with its position and other relations, indicate a soda-amphibole of the arfvedsonite group. Evidently we have here a gradual change in com-

position from a normal hornblende to one abnormally high in soda, brought about through contact with a magma, becoming increasingly rich in soda molecules. At times the arfvedsonite mineral is slightly decomposed.

The pyroxene presents nothing novel. Basal sections are rather frequent and exhibit the well-developed prismatic cleavages. It is of the augite variety. This, together with zircon, apatite, biotite, ilmenite, and magnetite, together with a scattering quartz, complete the list of original minerals.

In the vicinity of the amphibole, much iron oxide has separated. It is black in shade and irregular in outline. It has been derived from the hornblende, but the residual mass of this mineral appears perfectly fresh. Clouds of yellow ocher were noted, chiefly in the vicinity of the pyroxene, and from the analysis ilmenite also appears to be quite abundant. Fluid inclusions in the quartz are not uncommon.

The analysis of this rock follows:

ANALYSIS OF QUARTZ MONZONITE. (W. C. PHALEN, ANALYST.)

SiO <sub>2</sub> .....	67.27
Al <sub>2</sub> O <sub>3</sub> .....	13.67
Fe <sub>2</sub> O <sub>3</sub> .....	1.83
FeO .....	2.49
MgO .....	1.72
CaO .....	1.90
Na <sub>2</sub> O .....	2.79
K <sub>2</sub> O .....	5.80
H <sub>2</sub> O above 100° .....	.45
H <sub>2</sub> O below 100° .....	.08
TiO <sub>2</sub> .....	1.70
P <sub>2</sub> O <sub>5</sub> .....	.16
MnO .....	.19
	100.05

## PART II

### INTRODUCTION

During the preparation of this article a new rock classification has appeared, based on the chemical relations which obtain in igneous rocks.<sup>1</sup> It was decided by the writer to incorporate the principles of this classification into the body of this present theme, in so far as they were applicable, but on maturer thought this was deemed inadvisable for the following reason. It was held that to introduce so much of an entirely new nomenclature into an article where an old and familiar group of names must of necessity predominate at

<sup>1</sup> *Quantitative Classification of Igneous Rocks*, by Cross, Iddings, Pirsson, and Washington. Chicago, 1903.



the present time must only tend to obscure and to detract attention from the main topic at issue. At any rate, with this idea in view, it was decided to append a second chapter, devoted chiefly to the discussion of the rock analyses and their interpretation in the light of the work already alluded to.

UMANAK ISLAND

*Granite* (Cat. No. 75,480).—Directly back of the low-lying expanse which has been described as stretching a mile back from the coast<sup>1</sup> there rises, to a height of 3700 feet, a typical nunatak, composed of granite. An analysis of this granite, comprising the boss, follows, and with it an analysis of graphic granite from Omeo, Victoria, Australia, by A. W. Howitt.

ANALYSIS OF GRANITE—OMEOSE

	(1)	(2)
SiO <sub>2</sub> .....	76.03	70.91
Al <sub>2</sub> O <sub>3</sub> .....	12.02	15.32
Fe <sub>2</sub> O <sub>3</sub> .....	.69	trace
FeO .....	.68	—
MgO .....	.18	.07
CaO .....	1.61	.58
Na <sub>2</sub> O .....	2.97	2.31
K <sub>2</sub> O .....	5.72	10.07
H <sub>2</sub> O .....	.20	.51
TiO <sub>2</sub> .....	.28	—
	100.38	99.77

NOTE.—1. Greenland granite, W. C. Phalen, analyst. 2. Graphic granite, Omeo, Victoria, Australia, A. W. Howitt, analyst. *Trans. Roy. Soc. Victoria*, XXIV, pt. II, p. 120, 1888.

COMPOSITION IN TERMS OF STANDARD MINERALS

	(1)	(2)
Quartz .....	34.38	18.00
Orthoclase .....	33.92	59.49
Albite .....	24.63	19.39
Anorthite .....	2.78	1.67
Ilmenite .....	.61	—
Magnetite .....	.93	—
Diopside .....	1.57	.66
Wollastonite .....	1.39	—
H <sub>2</sub> O .....	.20	.51
	100.41	99.72

According to the quantitative scheme of classification the rock works out to an omeose, a rock very high in silica and potash, granitic in every respect.

<sup>1</sup> See page 186.

It will be noted that the analyses show rather wide discrepancies, only the wide ranges in the ratios involved in the classificatory scheme allowing them to be placed in similar subdivisions; thus, for example, in the Greenland rock, the ratio Q:F is 0.6, in the graphic granite from Omeo it is 0.22. The ratio between the alkalis and lime in the former case is 15.5, and that between the potash and soda is 1.9; these respective ratios in the type omeose being 30 and 4.

*Diorite* (Cat. No. 75,481).—The diorite has been described as forming a series of horizontal dikes in the granite and as varying in texture from a very fine grain to a pegmatitic facies. The lower dike material has been chosen as a type of the magma, from which all the diorites have come for the reasons stated on page 190 of this article. Its analysis, therefore, is given with that of von Lasaulx's doleritic lava from Auvergne, the diorite having worked out to an auvergnose.

## ANALYSES OF DIORITE—AUVERGNOSE

	(1)	(2)
SiO <sub>2</sub> .....	47.80	48.57
Al <sub>2</sub> O <sub>3</sub> .....	18.24	19.47
Fe <sub>2</sub> O <sub>3</sub> .....	.35	—
FeO .....	9.27	13.53
MgO .....	8.08	4.25
CaO .....	11.44	10.86
Na <sub>2</sub> O .....	2.24	1.33
K <sub>2</sub> O .....	*.45	.82
H <sub>2</sub> O above 100° .....	.58	.48
H <sub>2</sub> O below 100° .....	—	
TiO <sub>2</sub> .....	1.46	—
P <sub>2</sub> O <sub>5</sub> .....	.24	—
MnO .....	.55	.76
	100.70	100.07

NOTE.—1. Diorite (Auvergnose) Greenland, W. C. Phalen, analyst. 2. Doleritic lava from Auvergne, A. v. Lasaulx, analyst. *Neues Jahrbuch f. Min., Geol. u. Pal.*, 1869, p. 657.

## COMPOSITION IN TERMS OF STANDARD MINERALS

	(1)	(2)
Orthoclase .....	2.78	5.00
Albite .....	18.86	11.00
Anorthite .....	38.09	44.76
Ilmenite .....	2.89	—
Magnetite .....	.70	—
Apatite .....	.31	—
Diopside .....	14.56	7.83
Hypersthene .....	5.01	25.62
Olivine .....	16.96	5.45
H <sub>2</sub> O .....	.58	.48
	100.77	100.14

Though the analyses show such discrepancies, especially so as regards the content of the iron oxides and magnesia, the ratios involved in the placing of the rock in its classificatory position are very close. The auvergnose from the type series of von Lasaulx however, would, strictly speaking, be placed in the sodi potassic subrang of the rang auvergnase, owing to a ratio value between the alkalis of 0.61, this ratio, in the Greenland rock, being 0.2.

## NUGSUAKS PENINSULA

On page 195 there is described a rock (Cat. No. 75,488), which has been referred to as lying loose just back of Kaersut. Such material is not regarded as having very great petrographic value. Nevertheless, since the type is rather limited, so far as its exposures in the earth's crust are known, it was deemed worthy a partial analysis to ascertain its classificatory position. From the results of this chemical examination, which follow, it will be seen that the rock is very basic, that it belongs to class IV, the dofemane class, section four of the order hungarare, and to the domagnestic subrang of section one in the permirlic rang of this order. Its name therefore is custerose.

## PARTIAL ANALYSIS OF PERIDOTITE—CUSTEROSE

	(1)	(2)
SiO <sub>2</sub> .....	42.63	46.03
Al <sub>2</sub> O <sub>3</sub> .....	6.88	9.27
Fe <sub>2</sub> O <sub>3</sub> .....	3.33	2.72
FeO .....	7.27	9.94
MgO .....	29.36	25.04
CaO .....	5.90	3.53
Na <sub>2</sub> O .....	1.26	1.48
K <sub>2</sub> O .....	.14	.87
MnO .....	.36	.40
NiO .....	.27	—
Cr <sub>2</sub> O <sub>3</sub> .....	.05	—
H <sub>2</sub> O .....	—	.64
P <sub>2</sub> O <sub>5</sub> .....	—	.17
	97.45	100.09

NOTE.—1. Partial analysis of peridotite (custerose), Greenland, W. C. Phalen, analyst. 2. Analysis of peridotite, near Querida, Silver Cliff, Custer Co., Col., L. G. Eakins, analyst. Cross, 17th Ann. Rep. U. S. G. S., pt. II, p. 284, 1896.

There remains but one rock, quartz monzonite, whose microscopic analysis is given on p. 206. This rock, whose chemical analysis is given as follows, proves to be a dellense.

## ANALYSIS OF QUARTZ MONZONITE—DELLENSE

	(1)	(2)
SiO <sub>2</sub> .....	67.27	68.36
Al <sub>2</sub> O <sub>3</sub> .....	13.67	13.24
Fe <sub>2</sub> O <sub>3</sub> .....	1.83	1.29
FeO .....	2.49	3.39
MgO .....	1.72	1.15
CaO .....	1.90	2.51
Na <sub>2</sub> O .....	2.79	2.05
K <sub>2</sub> O .....	5.80	5.34
H <sub>2</sub> O above 100° .....	.45	} 2.63
H <sub>2</sub> O below 100° .....	.08	
TiO <sub>2</sub> .....	1.70	—
P <sub>2</sub> O <sub>5</sub> .....	.16	—
MnO .....	.19	.27
	100.05	100.23

NOTE.—1. Quartz monzonite—Greenland, W. C. Phalen, analyst. 2. Glassy andesite—Dellen, Sweden, H. Santesson, analyst. F. Suenonius, Andesite from Helsingland, Sweden, *Geol. För. Förh.*, x, 1888, p. 273.

## COMPOSITION IN TERMS OF STANDARD MINERALS

	(1)	(2)
Quartz .....	22.32	26.83
Orthoclase .....	34.47	31.14
Albite .....	23.58	17.29
Anorthite .....	7.51	11.12
Apatite .....	.34	—
Ilmenite .....	3.19	—
Magnetite .....	2.55	1.86
Diopside .....	.88	1.18
Hypersthene .....	4.68	7.98
Water .....	.53	2.63
	100.05	100.08

From the analysis of this quartz monzonite, it will be seen that the silica is rather high. This is explained in part by the presence of free quartz. Low lime indicates a small amount of basic feldspar. The high content of titanitic acid is worthy of mention.

In the main, the analysis agrees fairly well with that of the type rock from Sweden. Notable differences occur, however, in the content of ferrous oxide, water, and titanitic acid; the differences in the first and third substances, however, do not suffice to alter the classificatory position, since in rocks of the first three classes these oxides do not have the weight which they possess in similar divisions of classes four and five.

NOTE.—In conclusion, I wish to express my appreciation of the many courtesies extended to me during the course of this work by Dr. G. P. Merrill, Dr. Wirt Tassin, and Mr. Chas. Schuchert, of the U. S. National Museum, and by Dr. David White of the United States Geological Survey.

June 9, 1903.

## NOTES

### INTERNATIONAL CATALOGUE OF SCIENTIFIC LITERATURE

The International Catalogue of Scientific Literature consists of a classified subject and author catalogue of all original scientific literature beginning with January 1, 1901. All of the seventeen sciences named below are included within the scope of the catalogue, one volume a year being devoted to each: Mathematics, mechanics, physics, chemistry, astronomy, meteorology (including terrestrial magnetism), mineralogy (including petrology and crystallography), geology, geography (mathematical and physical), paleontology, general biology, botany, zoology, human anatomy, physical anthropology, physiology (including experimental psychology, pharmacology and experimental pathology), and bacteriology.

The organization consists of a central bureau in London (Dr. H. Forster Morley, Director) to edit and publish classified references to the world's current literature furnished by regional bureaus established in and supported by the principal countries of the world. The system of classification adopted divides each science into specific, numbered subdivisions, under one or more of which it is possible to classify any paper on any subject within the domain of science. Conversely, when any subject is to be investigated, the plan is first to find the subject-heading in the classification schedule and to use the number there given instead of a page number in looking up the grouped references in the body of the catalogue, the pages of which bear the schedule numbers in addition to page numbers. As, with the exception of additions, these subdivisions and numbers are the same from year to year, this method will materially aid in investigations covering a term of years.

Regional bureaus are established in the following countries: Austria, Belgium, Canada, Cape Colony, Denmark, Egypt, France, Great Britain and Ireland, Germany, Greece, Holland, Hungary, Italy, India and Ceylon, Japan, Mexico, New Zealand, New South Wales, Norway, Portugal, Poland, Queensland, Russia, South Australia, Sweden, Switzerland, Victoria, Western Australia, and Finland. Authority over all questions of methods and administration is vested in an international convention to be held in London in 1905, 1910, and every tenth year following.

Failing in governmental appropriation for the establishment of a regional bureau in the United States, the Smithsonian Institution felt obliged to render its fostering aid to the project, otherwise the enterprise might have been abandoned. The Institution was at the time enabled to devote a sum of money to carry on the work here provisionally, which, together with gratuitous aid, rendered it possible to make a start. The limited means at the disposal of the Institution at first greatly hampered the work in this country, but, beginning with July 1, 1903, it was possible for the Institution to devote a sum of money to the purpose which had hitherto been otherwise employed. This will not only enable the Institution to deal more promptly with the current publications in the United States, but will render it possible to make good the omissions occurring from January 1, 1901, to the present time.

With the exception of zoology all of the volumes of the first year's issue of the catalogue have been published, together with astronomy of the second year's issue.

It was at first hoped that valuable aid for the work in the United States could be obtained from existing card indexes in the different scientific branches of the government, but experience has shown that, owing to the dissimilar methods used, it is practically as difficult to transpose, verify, and properly classify the references obtained in this manner as it is to procure the data at first hand.

To give some idea of the extent of the work in this country it may be said that approximately 27,000 classified reference cards have been forwarded by the Smithsonian Institution to the London central bureau.

The method here employed is briefly this: A numbered card record file is kept of the titles of the periodicals published in the United States which are likely to contain matter on scientific subjects; this record is systematically gone over at regular intervals and the periodicals called for from the Smithsonian library, which aims to receive all such publications. The contents of the publications themselves are indexed separately on cards, and each card duplicated as many times as necessary in order to send to the central bureau (besides the regular reference by authors' names) one card for each of the subjects into which the paper is classified. Duplicate author reference cards, on which are noted the assigned classification, are kept for file, and a record is kept of the entire publication on the periodical cards referred to. By this method it is possible not only to duplicate the work at any time, but to check and make good any omissions.

Separate publications and books are treated in like manner in regard to classification, although the methods of obtaining notice of their appearance is necessarily different.

To classify properly into minute subdivisions, such as are employed in this work, the vast amount of scientific matter appearing in this country is a difficult task, but every effort is used to make the references exact, and where an intricate question is involved the advice of a specialist is asked. At the central bureau a corps of referees are employed, a specialist for each science, who, to guard against error, review each reference before publication.

This catalogue now furnishes aid to both librarians and students who have long needed a concise subject index to the great and ever-increasing scientific literature of the day.

The United States leads in the number of subscribers to the catalogue, the number being 97, equivalent to over 72 complete sets. The yearly subscription to the full set of seventeen volumes is \$85. The individual volumes may be subscribed to for a sum *pro rata* to the cost of the full set.

#### SMITHSONIAN SEAT AT NAPLES

DR. CHARLES SEDGWICK MINOT, Professor of Histology and Embryology in Harvard University, occupied the Smithsonian Table at the Naples Zoological Station in the autumn of 1902, devoting his time to procuring extensive series of embryos of *Torpedo ocellata*, *Mustelus laevis*, *Petromyzon*, and *Amphioxus*, and young stages of *Pristiurus* and *Scyllium*. Owing to the exceptional opportunities for procuring collections at the Station, Doctor Minot reports that he was able to obtain fine series of carefully selected stages of specimens, which, arranged in serial sections, have been added to the embryological collections at Harvard University, where they will be accessible to all competent investigators, and will serve for many years for researches in comparative embryology.

DR. CHARLES W. HARGITT, of Syracuse University, was granted the occupancy of the Smithsonian Table at the Naples Zoological Station for the months of March, April, and May, 1903, during which period it was possible for him to finish a research on the early development of *Eudendrium*, a genus of hydroids of whose development comparatively little has hitherto been known. The manuscript of the full report is now in the hands of the editor of the *Zoologisches Jahrbuch* for publication, and will probably appear during the current year. Doctor Hargitt found that while, in the main, the course of development in these hydroids is comparable with that

of others of similar character, there are many features which are unique. The early development of the eggs and their migration into the gonophores has long been known; but in manner of growth and the physiological phenomena associated therewith, some rather unusual changes take place, which have not been generally recognized. In the phenomena of egg cleavage there seem to be peculiarities known only of special cases among other groups of invertebrates, which are probably due to very similar conditions in the history of the eggs. Doctor Hargitt has likewise found among this group of coelenterates rather distinctive peculiarities, not hitherto recorded, as to the later cleavage phase and the formation of the germ layers of the embryo, which have an important bearing on problems of phylogenetic and speculative character.

#### THE NOBEL PRIZES

The following data relative to the Nobel Peace Prize, to be awarded December 10, 1904, have been officially communicated to the Institution.

This prize may be accorded to institutions, associations, or individuals: The names of candidates for the 1904 prize must be proposed to the Nobel Committee of the Norwegian Parliament, before February first of that year, by one of the following named persons, who are held to be duly qualified for such action:

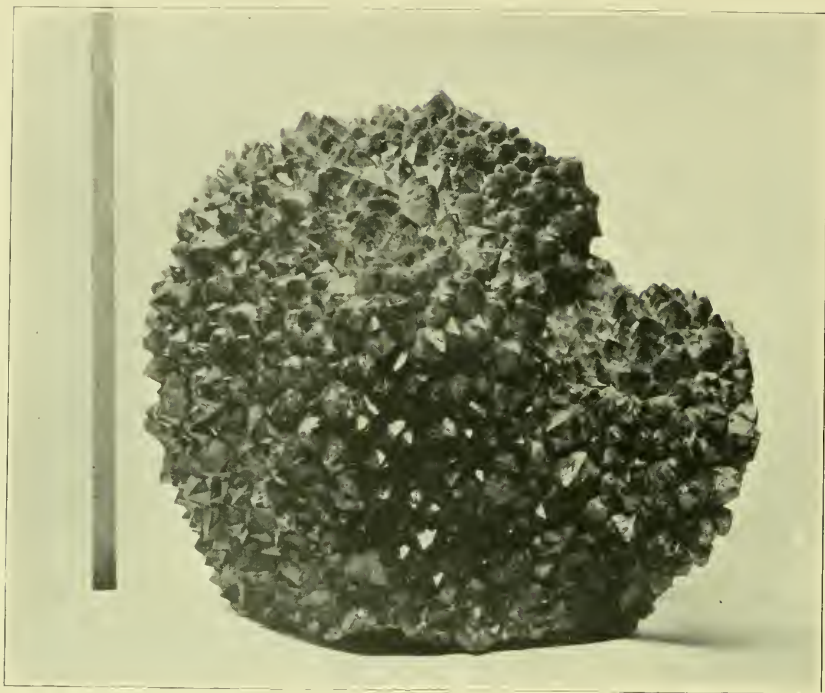
Members of the Nobel Committee; members of parliament and government officials of different countries; members of the inter-parliamentary council; of the commission of the International Peace Bureau, and of the Institute of International Law; university professors of political science, of law, history, or philosophy, and persons who have received the Nobel Peace Prize.

A statement of the grounds on which the proposal of a candidate is based should be submitted, with any related documents referred to. Only the printed works of a candidate are accepted as credentials for a prize. Further particulars as to the award may be obtained by application to the Nobel Committee of the Norwegian Parliament, Victoria Terrasse 4, Kristiania.

The Institution has also been officially informed that the Nobel prize in physics for 1901 was awarded to Prof. W. C. Röntgen of the University of Munich, for the discovery of the rays which bear his name. The prize in physics for 1902 was equally divided between Prof. H. A. Lorentz of the University of Leyden and Prof. P. Zeeman of the University of Amsterdam, for their researches on the influence of magnetism on the phenomena of radiation.







CLUSTER OF AMETHYSTINE QUARTZ FROM RIO DO SUL, BRAZIL.  
(Weight 400 lbs., height 24 in., breadth 27 in.)



GIANT QUARTZ CRYSTAL FROM CALIFORNIA.  
(Weight 309 lbs., height 18 in., length 30 in.)

The Nobel prize in chemistry for 1901 was awarded to Prof. J. H. van't Hoff, of the University of Berlin, for the discovery of the laws of dynamic chemistry and of osmotic pressure in solutions. The prize in chemistry for 1902 was awarded to Prof. E. Fischer, of the University of Berlin, for his synthetic researches in the groups of sugars and of purines.

#### GEOLOGICAL COLLECTING EXPEDITION

DR. GEORGE P. MERRILL, Head Curator of the Department of Geology of the National Museum, left Washington on August 16th and returned October 2d, going first to Ishpeming, Michigan; thence to Portland, Oregon, from which point he proceeded in turn to San Francisco, Ogden, Salt Lake, Pocatello, Laramie, and Denver. Field excursions for the purpose of obtaining collections were made in the Bad-lands of North Dakota, the Lower Madison valley of Montana, and near the town of Opal in southwestern Wyoming.

At Ishpeming was obtained a large and exceptionally fine series of the remarkable contorted and brecciated hematite jaspers, such as have been described by Dr. C. R. Van Hise in volume XXVIII of the Monographs of the United States Geological Survey. From the Quaternary bluffs on the Lower Madison river, in Montana, was obtained a large series of the beautiful wood opal for which this locality is noted, and from southwestern Wyoming an extensive series of the peculiar hot-spring deposits in the form of cylindrical trunk-like masses, lined with quartz, agate, and calcite.

Through the generosity of Messrs. J. R. Wharton and A. P. Pohndorf, of Butte, Montana, there were obtained some fine examples (the largest 24 inches in length) of the smoky quartzes found in the Little Pipestone district, Silver Bow county. In San Francisco there was procured a magnificent milky quartz, measuring about 30 by 18 inches and weighing 309 pounds. In size and crystalline development this is believed to be one of the finest specimens of the kind in the United States. (See plate LVI.)

From dealers in San Francisco, Denver, Manitou, and Deadwood was obtained much miscellaneous material, the more important being a large mass of Wyoming moss agate, weighing 536 pounds. Through the courtesy of Messrs. Robert Forrester and W. B. Putnam, there were obtained small but exceptionally fine series of cave aragonites from silver mines in Utah.

The trip, on the whole, was highly profitable, material being obtained which probably could never have been brought to the Museum

through the ordinary channels of trade or through collectors, owing to the expense of getting it out or to lack of knowledge concerning the needs of the Museum and the possibilities of its exhibition series.

#### A REMARKABLE AMETHYST GROUP

Among the numerous accessions by the Department of Geology of the National Museum, few are of more striking interest than a recently received large and remarkably perfect group of amethystine quartz from the well-known Brazilian locality of Rio do Sul. The specimen weighs approximately 400 lbs., and, as shown in the accompanying illustration (plate LVI), is in the form of a botryoidal mass completely studded with short but broad pyramidal terminations, the prism faces showing but slightly. In size the crystals are remarkably uniform, varying from 30 to 50 millimeters in breadth and some 25 millimeters in height. The color is deep amethystine, fairly uniform, and the points, considering the great weight of the specimen and the distance of transportation, are in an exceptional state of preservation. So far as records show, this is one of the largest if not the largest group of its kind in existence. It will form a part of the exhibit of the Department of Geology at the approaching Louisiana Purchase Exposition.

#### INTERNATIONAL EXCHANGES

There was an unusual increase in exchange transmissions to and from every part of the civilized world during the year ended June 30, 1903, being an excess over the previous year of 24,421 packages, or 19 percent. The total weight aggregated 559,718 pounds for the same period, or an increase of 41 percent over that of the fiscal year 1901-02. The countries which have most extensively coöperated with the United States in the interchange of official and scientific publications are Great Britain and Germany. The results of the year ended June 30, 1900, show that more parcels were exchanged with the former than with the latter, but subsequently Germany exceeded Great Britain until the year 1903, when Great Britain again took the lead. It is of interest to note that the total difference in the number of parcels exchanged between the United States and each of these great countries during the last four years is but 344.

#### IRON MINE AT LESLIE, MISSOURI

In April Mr. W. H. Holmes made a visit to Leslie, Missouri, for the purpose of studying certain traces of ancient operations re-

ported to occur in an iron mine near that place. Most interesting phenomena were encountered, the ancient aborigines having penetrated the ore body in many directions and to surprising depths, the purpose being, apparently, to obtain the red and yellow iron oxides for paint. Many hundreds of mining tools of stone were found in the ancient tunnels. The Leslie iron mine study has an interesting bearing on the technic and industrial history of the tribes. It has been a matter of much surprise, as the investigations of the ancient mining and quarrying have progressed, that the aborigines, seemingly so non-progressive and shiftless, should have conceived and carried out really great enterprises. The technical knowledge and skill displayed are of a low order indeed, but the work accomplished indicates remarkable persistence and demonstrates the existence of native capacity of high order.

#### EXCAVATIONS AT LANSING, KANSAS

In October, 1903, explorations were undertaken at Lansing, Kansas, with the view of determining the age of the human remains found embedded in loess-like formations near that place. The formations were extensively trenched by Mr. Gerard Fowke under the direction of Mr. William H. Holmes, and the conclusion was reached that the remains were of exceptional antiquity for America, but that they could not with certainty be assigned to a definite geological horizon, and that they were probably of post-glacial time. The purpose of the excavation was to expose the formations containing the human remains so fully that geologists of all ways of thinking might study them to advantage, thus preventing the adoption of conclusions based on inadequate observations. An account of Mr. Holmes' researches in this interesting field appears in the *Smithsonian Report* for 1902. The geological problems connected with this site have been exhaustively treated by Prof. T. C. Chamberlin in the *Journal of Geology*, Chicago, vol. x, No. 7.

#### FOSSIL BONE-BEDS AT KIMMSWICK, MISSOURI

Mr. W. H. Holmes, Chief of the Bureau of American Ethnology, with the assistance of Mr. Gerard Fowke, has made examinations of the fossil bone-beds at Kimmswick, Missouri, with the view of determining whether there was satisfactory evidence that man was contemporaneous with the mammoth and the mastodon in that region. These researches dealt with the important and ever-recurring question of the antiquity of man in America. It has been the aim of the Bureau of American Ethnology, and especially of the present

Chief, to occupy conservative ground with respect to this subject and to so fully scrutinize the discoveries and reputed discoveries reported from time to time that erroneous interpretations should not prevail. No traces of man were found in direct association with the fossil remains.

#### A STUDY OF THE SWORD

Mr. Paul Beckwith, Aid in the Section of American History, United States National Museum, is at present making a thorough study of the sword and other cutting and thrusting edged weapons. A large number of these weapons belonging to civilized nations have come into the possession of the National Museum through the War Department. Many swords of different types from southeastern Asia, Malaysia, the Philippine islands, and the West Indies have been acquired through the kind interest of army officers in those areas. With the material already in hand it will be possible to cover the history of the evolution of this most interesting weapon.

#### QUARRIES IN THE SOUTH AND WEST

Early in May Mr. William H. Holmes made a trip to Georgia and Alabama for the purpose of examining quarry sites and caverns anciently occupied by aborigines. Examinations of aboriginal flint quarries and sites of stone implement manufacture were also made by Mr. Holmes in southern Indiana and in eastern Kentucky.

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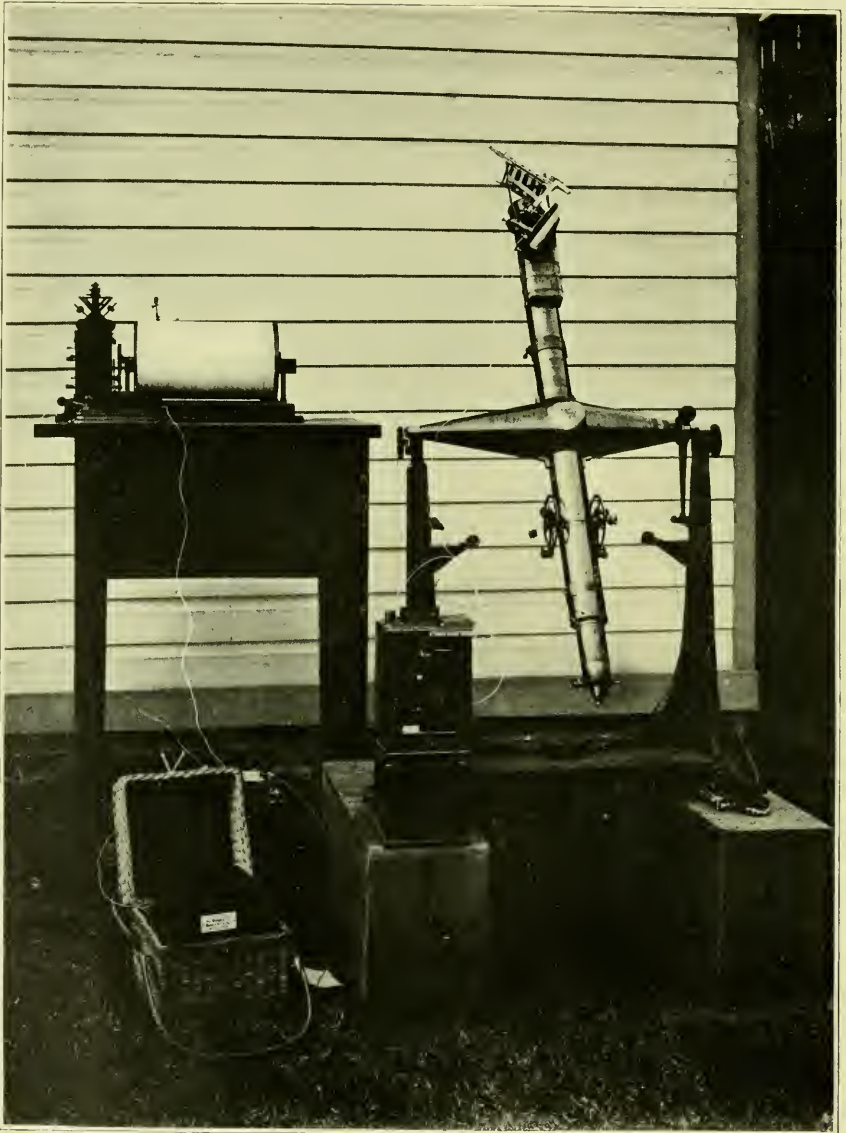
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THE PERSONAL EQUATION MACHINE, TRANSIT, CHRONOMETER, AND CHRONOGRAPH.

# SMITHSONIAN

## MISCELLANEOUS COLLECTIONS

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QUARTERLY ISSUE

OCTOBER-DECEMBER, 1903

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### A METHOD OF AVOIDING PERSONAL EQUATION IN TRANSIT OBSERVATIONS

BY S. P. LANGLEY

Many years ago the writer devised and published<sup>1</sup> preliminary accounts of a method for avoiding the so-called "personal equation" in observations of the time of transit of stars. The following quotation from the article cited will give the fundamental idea described in the former article, to which the present one adds some more recent experiments and slight modifications. The writer, after speaking of the comparative merits of and objections to a photographic method, and one where the star is seen intermittently projected on wires which are illuminated by consecutive flashes, observes:

"There is one particular case, however, where the result is the same for both, that, namely, where when the flash comes, the star is on the wire and bisected by it; in this case we know its position as accurately by the eye, as if we bisected its image on the plate by the wire of our micrometer. If we suppose, then, that by a happy accident, the flash came just as the star was crossing the first wire, this wire would be sharply defined on the disc of the star and bisecting it, and a simultaneous record on the chronograph (made without the intervention of the observer) would evidently give us the same result as though the star had recorded its own passage by an electrical contact. Further, we may particularly notice that it is immaterial whether the star was at rest, when thus seen, or in motion. Now what we have just supposed as a single case of a favorable chance among hundreds, it will be our task to *make* occur, whatever the wire interval, and for any star observed."

In illustration let it be imagined that the observer is watching the passage of the star through the field of his telescope, but that

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<sup>1</sup> *American Journal of Science and Arts*, July, 1877, pages 55-60.

he has no illumination of that field sufficient to discern the wires of the tally. Suddenly a flash illuminates the field, and we may suppose that by accident this occurs just at the instant when the star image is bisected by the central wire. If now the flash had recorded itself automatically on the chronograph, an observation independent of the ordinary personal equation would have been obtained, since we know where the star was at that recorded time of observation.

The device I have already described consisted in making this unlikely accident occur for any star, and for numerous wires of the tally.

At the time when it was first devised, such a method consisting not in correcting time observations for personal error committed, but in preventing the committal of such errors, was unique, and it had for the writer the good fortune of attracting the interest and commendation of Professor Clerk Maxwell. But the writer was prevented by distinct duties from developing it, and more recently Repsold and others have attacked the same problem in another way, with much success. Still it is possible that this older method may prove of value, and I have thought best to give this brief account of some recent trials of it.

The instrument whose purpose is to illuminate the field at the required instants, was constructed from my design by A. Hilger, as follows: A conical pendulum consisting of a graduated rod with a heavy ball which may be set at any height on the rod, is suspended by two pairs of thin flat springs acting as a universal joint. At the lower end of the rod is a needle which, as the pendulum revolves, governs the rotation of a grooved arm carried by a clock-work which also drives a drum carrying fine platinum brushes which make instantaneous electrical contacts at each revolution. (Plate LVII.) Thus the intervals between these contacts are governed by the rate of the conical pendulum, which itself goes fast or slow according as the ball is raised or lowered on the rod, this rod being graduated so as to correspond with the declination of any star between  $0^{\circ}$  and  $60^{\circ}$ . Knowing the declination of the star, it can be arranged beforehand, therefore, that the interval between contacts is equal to the average interval between transits of the observed star across the successive wires of the tally. By appropriate electrical connections this system of contacts is caused to produce a system of instantaneous discharges in a vacuum tube, which is used in place of a lamp to illuminate the cross wires of the telescope, and if the star be first seen, for instance, half way between the first and second

wires of the tally, it will be seen at the second illumination half way between the second and third wires, and so on.

We have thus arranged that flashes shall occur at recorded instants, without limit as to number, and at intervals such that if one, by chance, occurs when the star is bisected by a wire, it will be seen bisected by all the wires in succession. It now remains to arrange that this bisection shall actually occur. This is accomplished by providing an independent control of the position of the contact points under the clockwork, so that with a cord in the hand of the observer he can cause the series of contacts to occur sooner or later, without altering the interval regulated by the pendulum. Thus if the flash comes a little too early for bisection of the star image by the first wire of the tally, a slight adjustment is made, delaying the succeeding flashes, and with a little practice one or two adjustments suffice to secure bisection. To add the weight of independent observations, several displacements and readjustments may be made during the passage of the star over the tally.

As the times of all the flashes are recorded automatically upon the chronograph, an independent signal is made by the observer to mark each flash which has revealed a satisfactory bisection.

I have thus far given the device substantially as described in the early paper. To test the value of the method under circumstances admitting of distinguishing error, an artificial star was arranged to move by an accurate clockwork at about the apparent rate of an actual equatorial star. The shaft which carried the screw by means of which the artificial star was moved, had upon it an arm provided with an adjustable point which instantaneously broke an electrical circuit at each revolution. By careful adjustment, *with the artificial star stationary*, it was arranged that exact bisection took place at the middle wire of the tally, and with the point in position to break contact. Thus the artificial star was caused to record its own time of transit upon the chronograph wholly without personal equation of time.

A transit instrument of  $2\frac{3}{4}$  inches aperture and 48 inches focal length was kindly loaned me by the Superintendent of the United States Coast and Geodetic Survey, for the purpose of making an experimental test of the personal equation machine.

In reconsidering the theory of the method a possible cause of failure appeared. The observer sees the star continually moving across the limited field of view, and thus his mind may unconsciously be influenced by the perception of motion, just as it undoubtedly is in observations by the usual method. In order to

## TEST OF PERSONAL EQUATION MACHINE USED BY IMPROVED METHOD.

Method	Observer, C. G. A.						Observer, F. E. F.						Observer, N. E. C.					
	Usual Method Without Personal Equation Machine			With Personal Equation Machine Intermittently Obscuring Star			Usual Method Without Personal Equation Machine			With Personal Equation Machine Intermittently Obscuring Star			Usual Method Without Personal Equation Machine			With Personal Equation Machine Intermittently Obscuring Star		
	Error of Observed Time of Transit	Deviation From Mean Error	July 25, 1902	Error of Observed Time of Transit	Deviation From Mean Error	July 25, 1902	Error of Observed Time of Transit	Deviation From Mean Error	July 25, 1902	Error of Observed Time of Transit	Deviation From Mean Error	July 25, 1902	Error of Observed Time of Transit	Deviation From Mean Error	July 25, 1902	Error of Observed Time of Transit	Deviation From Mean Error	July 25, 1902
1	-.08	.034	0 <sup>s</sup> .004	-.08	.004	0 <sup>s</sup> .002	+.08	.03	0 <sup>s</sup> .08	+.08	.02	0 <sup>s</sup> .08	+.08	.02	0 <sup>s</sup> .086	-.08	.004	0 <sup>s</sup> .033
2	-.20	.094	.066	+.05	.066	.068	-.09	.068	.03	.03	.06	.046	.046	.046	+.06	.040	.011	.085
3	-.14	.034	.026	.01	.026	.078	-.10	.078	.02	.02	.04	.066	.066	.066	-.056	-.056	.085	.021
4	-.06	.046	.086	.07	.086	.032	+.01	.032	.11	.11	.20	.094	.094	.094	+.008	+.008	.021	.022
5	-.05	.056	.016	.00	.016	.058	-.08	.058	.05	.05	.00	.106	.106	.106	+.007	+.007	.022	.027
6	-.12	.014	.044	-.06	.044	.008	-.03	.008	.08	.08	.18	.074	.074	.074	+.002	+.002	.027	.041
7	-.18	.074	.034	+.05	.034	.038	-.05	.038	.05	.05	.10	.076	.076	.076	-.012	-.012	.041	.025
8	-.09	.016	.014	.03	.014	.082	+.06	.082	.03	.03	.05	.056	.056	.056	+.054	+.054	.025	.036
9	-.20	.094	.076	+.06	.076	.002	-.02	.002	.03	.03	.16	.054	.054	.054	+.007	+.007	.036	.091
10	-.13	.024	.084	-.10	.084	.118	-.14	.118	.04	.04	.25	.144	.144	.144	+.120	+.120	.091	.029
11	+.01	.116	.104	-.12	.104	.052	-.03	.052	.03	.03	.26	.154	.154	.154	+.058	+.058	.029	.056
12	-.01	.096	.064	-.08	.064	.082	+.06	.082	.07	.07	.10	.066	.066	.066	+.085	+.085	.056	.020
13	-.06	.046	.046	+.09	.046	.112	+.09	.112	.08	.08	.13	.076	.076	.076	+.049	+.049	.020	.001
14	-.04	.066	.066	-.03	.066	.008	-.03	.008	.02	.02	.07	.030	.030	.030	+.030	+.030	.001	.034
15	-.12	.014	.064	-.08	.064	.008	-.03	.008	.03	.03	.02	.063	.063	.063	+.063	+.063	.034	.002
16	-.17	.064	.064	-.08	.064	.008	-.03	.008	.03	.03	.02	.063	.063	.063	+.063	+.063	.034	.002
Mean.	-.0106	0.055	0.052	-.0016	0.052	0.053	-.0022	0.053	0.050	0.050	+.0106	0.080	0.080	0.080	+.0029	+.0029	0.033	0.033



overcome this objection a rearrangement of the apparatus was made so that instead of intermittently obscuring the wires of the tally, the wires were now continuously illuminated as in the usual method, but the star itself was obscured by a shutter, except at the instants when the wires had formerly been illuminated by the glow tube. As thus modified the observer by this second method sees the star only during well-separated intervals of a hundredth of a second or less, so that all appearance of motion is avoided. This device, suggested by Mr. Abbot, appears to be an improvement on the former method, and has been used in the observations presented in the accompanying table. These observations were made by three observers, C. G. A., F. E. F., and N. E. G., of whom F. E. F. was most experienced in observing transits without the personal equation machine, and accustomed to its use by the former method, but less practiced than the others with the machine as now employed.

The general result appears to be in favor of the personal equation machine. In the case of the observer C. G. A., whose usual equation was about  $-0.10$  seconds when observing without the machine, the error became only  $-0.016$  seconds with the machine; and the average deviation was reduced slightly. Similarly with the observer N. E. G., whose direct observations were usually rather variable, but which now yielded an average personal equation of  $+0.106$  seconds, the employment of the machine was of marked advantage, reducing his personal equation from  $0.106$  to  $0.029$  seconds and the average deviation of it from  $0.080$  to  $0.033$  seconds. With the observer F. E. F., the usual personal equation was small and the average deviation of it was slightly reduced.

So far as it has been tried, then, the advantage of observing by the aid of this device seems to be marked.

ON A COLLECTION OF FISHES MADE BY MR. ALAN  
OWSTON IN THE DEEP WATERS OF JAPAN

BY DAVID STARR JORDAN AND JOHN OTTERBEIN SNYDER

The writers have recently received from Mr. Alan Owston, of Yokohama, well known as a shipmaster and as a collector in natural history, a very remarkable series of fishes obtained on long lines in the depths of Sagami bay and Suruga bay, Japan. The present paper contains notes on these species, together with field notes of Mr. Owston. The specimen of *Mitsukurina owstoni* and some of the others have been sent to the United States National Museum. The rest are in the collection of Leland Stanford Junior University.

Family SCYLLIORHINIDÆ

**PRISTIURUS EASTMANI** Jordan and Snyder, new species

“Gobozame” (Burdock Shark)

(PLATE LX)

One specimen, a female, 345 millimeters long, from off Izu. Type No. 7740, Ichthyological collection, Leland Stanford Junior University.

The body is very slender and elongate, the head small and narrow. Head measured to first gill opening  $6\frac{1}{2}$  in the total length; depth equal to half the distance between tip of snout and third gill opening,  $11\frac{1}{2}$  in total length. Snout  $2\frac{1}{5}$  in head, rather acutely pointed. Nostrils with pointed flaps on the edges, which meet and curve inward, making the nasal cavity tube-like with an outer anterior and an inner posterior opening; distance between outer anterior openings equal to cleft of mouth measured on upper jaw, or distance between anterior edge of eye and spiracle; distance between posterior openings equal to half the longitudinal diameter of eye. Width of mouth equal to length of snout; distance between anterior edge of mouth and tip of snout equal to distance between center of pupil and anterior gill opening, or to width of interorbital space. Teeth each with 7 acutely pointed cusps, the central of which is twice as high as the others; lateral cusps growing successively smaller toward outer edges of tooth; three central cusps

distinctly visible, the others partly covered by the gums. Upper surface of tongue and roof of mouth with minute prickles. Spiracle on a level with eye, its greatest width equal to its distance behind eye, one-half the width of the first gill opening. Length of gill area equal to distance between eye and first gill opening; second, third, and fourth gill openings about equal in width, the fifth narrowest. Skin closely covered with minute, trilobed scales, each of which has a central keel. Upper edge of tail with a keel beginning an eye's diameter behind base of second dorsal and extending posteriorly a distance somewhat greater than length of head; keel armed by two rows of enlarged, tooth-like scales, the inner edge of each scale having a sharp cusp; about three rows of scales similar to those of the body between the rows of larger ones.

First dorsal fin inserted above posterior edge of base of ventral, its distance behind tip of snout equal to  $2\frac{4}{5}$  times the length of head; length of anterior edge of fin equal to length of snout. Second dorsal inserted anterior to end of base of anal. Free edges of both dorsals straight. Caudal fin with a notch on the ventral edge near end of fin. Free edge of pectoral slightly convex; when depressed the fin reaches a little over half way between origin of pectoral and ventral. Ventrals sharply pointed posteriorly. Tip of anal reaching a vertical through posterior end of base of second dorsal.

Color in spirits brownish above with indistinct clouds of a deeper shade, the more conspicuous of which are located as follows: above and a little behind base of pectoral, midway between pectoral and ventral, below bases of dorsals, on upper edge of tail and on caudal fins. Dorsals dusky, their anterior edges dark brown. Anterior edges of caudal, anal, and pectorals dark brown. Free margins of dorsals and of anal white. Pectorals dusky above, the free margins white. Tongue and inside of mouth without dusky color.

The following measurements are in hundredths of the total length (snout to tip of caudal fin): Head measured to first gill opening .15; depth .085; depth of caudal peduncle .04; width of first gill slit .017; longitudinal diameter of eye .04; length of snout .07; anterior edge of mouth to tip of snout .065; distance between nostrils .02; width of mouth .075; length of anterior edge of first dorsal .07; of second dorsal .07; length of base of first dorsal .045; of second dorsal .05; distance from insertion of ventral lobe of caudal to notch .20; from notch to end of caudal .06; width of base of pectoral .05; length of anterior edge .09; length of base of ventral .07.

## Family PSEUDOTRIAKIDÆ

PSEUDOTRIAKIS ACRALES<sup>1</sup> Jordan and Snyder, new species

## Oshizame (Dumb Shark)

(PLATE LXII)

One example, 172 centimeters long, from off Toi in Suruga bay. Type No. 12,903, Ichthyological collection, Leland Stanford Junior University.

Depth of body at origin of first dorsal about  $9\frac{1}{5}$  in total length; head measured to first gill opening  $5\frac{1}{2}$ ; snout  $2\frac{1}{2}$  in head measured to first gill opening; width of interorbital space  $2\frac{4}{7}$ ; head broad and flat, the greatest width contained  $1\frac{3}{4}$  times in the length, the depth  $2\frac{2}{3}$ ; interorbital space slightly concave; orbit narrow and long, its diameter 8 in head, the skin below eye with a deep fold; spiracle elongate, the greatest width equal to half the diameter of orbit; width of space between spiracle and first gill opening  $3\frac{1}{3}$  in head; height of third gill opening equal to diameter of orbit; width of space between nostrils equal to distance between anterior edge of orbit and spiracle,  $4\frac{1}{5}$  in head; distance between anterior edge of mouth and tip of snout equal to space between anterior edge of orbit and middle of spiracle,  $3\frac{5}{6}$  in head; distance from angle of mouth to its anterior edge measured on upper jaw  $2\frac{1}{2}$  in head.

Teeth on jaws very small, in oblique rows, the obliquity more pronounced toward posterior part of jaws; rows on upper jaw widely spaced posteriorly. Teeth of upper jaw and of tip of the lower, each with a long, sharply pointed, median cusp; a smaller cusp on the outer posterior edge, one or two similar small cusps on the inner anterior edge, and a series of sharp ridges on the outer side; posterior to tip of lower jaw the ridges are less apparent, the central cusp grows smaller, the lateral ones larger, others being added until the teeth become broad and flat with serrated edges. Skin covered with a shagreen of minute, leaf-like prickles, each with a strong, elevated midrib—some of them with a slight denticulation on each side.

Distance between origin of first dorsal fin and tip of snout equal to  $4\frac{2}{3}$  times the length of space between eye and anterior gill opening; fin highest behind the middle, where its height is contained  $5\frac{1}{4}$  times in the length of base.

Distance between first and second dorsals equal to  $3\frac{1}{2}$  times the diameter of orbit; base of second dorsal equal to twice its height;

<sup>1</sup> ἀκραλής, speechless.

width of free edge of fin equal to height of fin. Insertion of anal slightly posterior to that of second dorsal, the length of its base equal to that of upper jaw, measured from angle of mouth to anterior edge; height of fin contained  $2\frac{1}{2}$  times in length of base; width of free edge a little less than height of fin.

Distance between anal and origin of caudal  $1\frac{1}{2}$  times diameter of eye; caudal with a deep notch on postero-ventral side, the distance between origin of fin and notch  $4\frac{2}{3}$  times depth of caudal peduncle at origin of fin.

Anterior edge of base of pectoral below third gill opening; width of base of fin  $3\frac{1}{3}$  in head; length 2. Origin of ventral on a vertical a little anterior to end of base of dorsal; length of anterior edge of fin  $2\frac{1}{3}$  in head; free edge 4.

Color on both dorsal and ventral surfaces dark gray; fins including the first dorsal edged with blackish.

This species seems to differ considerably from the Atlantic form *P. microdon*, Capello. The writers have not seen the original description and figure of *P. microdon*, but rely on that of Günther, after Capello, and also on an account of an example from Long Island, published by Bean.<sup>1</sup> Comparisons of measurements given by Bean and similar ones from the species in hand follow:

*P. microdon.*

Snout about twice as long as distance from its tip to mouth.

Tip of snout to last gill opening 5 times in total length.

Height of head at angle of mouth 11 times in total length.

The distance of mouth from snout measured on axis of fish equals one-third width of mouth. The distance from snout to angle of mouth obliquely taken equals one-fourth the distance from snout to last gill opening.

Distance between nostrils equals 4 times the distance between eye and spiracle.

*P. acrales.*

About  $1\frac{1}{2}$  times.

$4\frac{1}{3}$  times.

$14\frac{1}{2}$  times.

Distance from tip of snout to anterior edge of mouth  $1\frac{1}{8}$  in width of mouth; from tip of snout to angle of mouth  $1\frac{7}{8}$  in distance between tip of snout and last gill opening; from angle of mouth to its anterior edge measured on upper jaw, 3 times.

$2\frac{2}{3}$  times.

<sup>1</sup> Bean, Tarleton H. The first occurrence of *Pseudotriacis microdon*, Capello, on the coast of the United States. *Proc. U. S. Nat. Mus.*, vol. VI, 1883, p. 147.

Length of base of first dorsal  $5\frac{1}{4}$  times its greatest height,  
7 times its greatest height: some-  $9\frac{3}{5}$  in total length.  
what more than body height at  
origin of fin,  $8\frac{2}{7}$  in total length.

Height of second dorsal nearly  $2\frac{1}{3}$  times length of orbit.  
twice the length of orbit.

Distance of caudal from end  $2\frac{2}{3}$ .  
of anal base equals one-fourth  
the length of second dorsal base.

Greatest width of pectoral  $1\frac{2}{3}$ .  
equals twice height of anal.

#### Family MITSUKURINIDÆ

##### MITSUKURINA OWSTONI Jordan

##### Tenguzame (Goblin-Shark)

A huge example, 353 centimeters long, forwarded without examination to the United States National Museum. This is the third example taken, the first being in the Imperial University of Tokyo, the second in the Museum of Brussels. Mr. Owston writes:

"I have several duplicates of this now, but the one I send is the longest so far obtained. This shark is taken mostly at Kozu near Odawara—on the chart  $35^{\circ}.16 \times 139^{\circ}.17$  E. gives the exact spot, where it will be seen there is a bank with 52 fms. on it close to depths of 300 to 400 fms. I imagine these sharks come on to this bank to breed, as mostly females are taken, and in the spring-time only. They are caught in *naname* (7-mesh) nets, which are set at the upper edge of the bank, so catching the fish when they come up from the deep. Oil is extracted from the liver, but the flesh is used only for fertilizing purposes.

"This shark appears to be fairly well known at this particular spot only, where they call it *Tengu-zame*, Goblin or Elfin Shark. I showed a figure of it to half a dozen fish-mongers at Odawira, only four miles away, and not one of them had even seen or heard of such an animal. Kuma Aoki of Misaki knew nothing about this shark being found at Kozu, although I believe he has fished on the very ground. Kuma took a small one recently off Okinose, 10 miles south of Misaki, by shark lines, and they have been taken on the coast of Izu also by line."

#### Family LAMNIDÆ

##### ISUROPSIS GLAUCA (Müller and Henle)

##### Nezumizame (Rat-shark)

*Nesumi*, rat: "Probably meaning mouse-colored."

Suruga bay. The species is common in Japan.

## Family SQUALIDÆ

## LEPIDORHINUS FOLIACEUS (Günther)

## Kanatsubo-zame

One specimen in good condition from off Enoura in Suruga bay.  
 “*Kanatsubo* is a vulgar term for a peculiar facial expression.”

## Family CHIMÆRIDÆ

## CHIMÆRA PURPURASCENS Gilbert MS.

(Gilbert MS. Fishes Collected off Hawaii by the *Albatross*, 1902.)

## Kachizame

One specimen 132 centimeters, No. 12,902, Leland Stanford Junior University Museum, from off Mishina, Izu in Sagami bay.

Mr. Owston observes: “The fish is called Kachizame, the exact meaning of which I have not been able to ascertain. Kachi may mean ‘a kind of gray color.’ I have a duplicate specimen. They were of a fine purplish black when fresh.”

## Family PLAGYODONTIDÆ

## PLAGYODUS FEROX (Lowe)

(*Alcispaurus æsculapius* Bean)

Two well-preserved examples are from Misaki. Mr. Owston mentions the preservation of several duplicates and we have seen the same species in the Imperial University of Tokyo. A comparison of the Japanese specimens with some from the west coast of North America leaves little doubt as to the identity of *P. ferox* and *P. æsculapius* (Bean) with the Japanese species.

A specimen collected at Unalaska, Alaska, by Dr. Jordan, has 41 dorsal, 15 anal, and 8 ventral rays; another obtained near Point Arenas, California, by Mr. Elijah Bishop, and presented to the University by Prof. Robert E. Swain, has 38 dorsal, 15 anal, and 9 ventral rays. The Japanese examples have 35 and 36 dorsal, 15 anal, 10 and 9 ventral rays respectively. A specimen from San Luis Obispo county, described and figured by Miss Flora Hartley,<sup>1</sup> has 39 dorsal (39 in description, 37 in figure), 17 anal, 9 ventral rays. All the above have the first rays of dorsal, anal, and ventral spine-like, with the anterior edge more or less roughly serrated.

<sup>1</sup> *Proc. Cal. Acad. Sci.*, 1895, p. 49, pl. II.

## Family GONORHYNCHIDÆ

**GONORHYNCHUS ABBREVIATUS** Schlegel

Nezumi-Gisu (Rat-Gisu or Sillago)

(PLATE LIX)

A fine specimen from the Yokohama market.

The Japanese species seems to differ from that of the Australian seas (*Gonorhynchus gonorhynchus* = *G. gronovii* = *G. greyi* = *G. brevis*) in the constantly larger head. In the specimen here figured the head is  $4\frac{2}{5}$  times in length of body to base of caudal,  $4\frac{5}{6}$  times in total length. The depth is about half the length of the head. Eye  $4\frac{1}{2}$  in head.

Mr. E. C. Starks has examined the shoulder girdle of this species; it has the mesocoracoid arch, as usual with Isospondylous fishes. Its place is apparently with the earliest and most generalized of these forms.

## Family GEMPYLIDÆ

**PROMETHICHTHYS PROMETHEUS** (Cuv. and Val.)

Sumiyaki

Two specimens from off Izu; the name means "charcoal burnt." We obtained the same species in the market of Tokyo, from off Misaki.

## Family LABRIDÆ

**JULIS MUSUME** Jordan and Snyder, new species

(PLATE LXI)

Two examples, the type No. 8384, Ichthyological collection, Leland Stanford Junior University, and the cotype in the United States National Museum, both from off Izu.

Head measured to end of opercular flap  $3\frac{3}{5}$  in length to base of caudal fin; depth  $3\frac{2}{3}$ ; depth of caudal peduncle  $7\frac{1}{3}$ ; length of snout  $3\frac{1}{4}$  in head; diameter of eye  $6\frac{1}{3}$ ; width of interorbital space  $4\frac{2}{3}$ ; number of scales in longitudinal series, counting from upper edge of gill opening, 69; in transverse series upward and forward from origin of anal 31; dorsal IX, 12; anal III, 12.

Two rows of teeth in each jaw, the inner of which extends backward but a short distance, the teeth small and blunt; outer teeth acutely pointed, the anterior pair of each jaw elongate, the lower pair closely apposed, fitting between the upper ones; a small posterior canine projecting outward and forward from the upper jaw.

Gill-rakers on first arch 5 + 11, short; those on middle of lower limb of arch with sharp tips.



Lateral line curving upward from the edge of the opercle, passing along near the back on the fourth or fifth row of scales below the base of dorsal, curving downward below bases of eighth and ninth articulated rays and extending along middle of caudal peduncle.

Scales gradually growing smaller from the belly toward the breast, where they are minute and imbedded near the throat; a narrow naked area extending from nape to insertion of dorsal.

Dorsal spines graduated in length from the second to the last, the second one contained  $3\frac{5}{6}$  times in the head, the last  $2\frac{5}{6}$  times; first spine half as long as the last; middle rays of soft dorsal  $2\frac{1}{3}$  in the head. Anal spines weak, the third contained 4 times in the head; longest anal ray  $2\frac{2}{5}$  in the head; base of anal extending a little farther posteriorly than that of the dorsal; the tips of the fins when depressed reaching about an equal distance posteriorly, but not reaching the base of caudal. Membranes of dorsal and anal not notched between the rays. Caudal convex, its length  $1\frac{1}{2}$  in the head; scales extending outward between the rays on basal third of fin. Pectoral  $1\frac{3}{5}$  in head. Ventrals pointed equal in length to pectorals.

Color in spirits white on lower half of body, the head pearly white; a broad, dark, longitudinal stripe on upper half extending from tip of snout to near tip of caudal; upper border of stripe straight, passing from tip of snout through upper margin of eye, gradually approaching base of dorsal and nearly reaching it at end of fin; ventral border of stripe passing through lower margin of eye, interrupted on opercle by a downward projection from the stripe, and again along the side of body by 12 or more breaks made by tongues from the light ventral parts projecting up into the dark stripe. Dorsal black with a white border which is narrow anteriorly, growing broader and becoming diffused with the dark base of the fin posteriorly. Dark stripe of body broadening on caudal, the lower third, the posterior and upper margins white. Pectorals, ventrals, and anal white. Inside of mouth and gill chambers white.

A colored drawing sent by Mr. Owston illustrates the color in life as follows: Snout and occiput bright vermilion, the color diffused along the back and also on the pectoral and ventral fins; anterior part of spinous dorsal, sides, and belly with lemon yellow, the color more intense at base of pectoral, between ventrals, along anterior half of base of anal, and along the lower, irregular edge of the dark, lateral stripe; middle of caudal with a dash of orange.

## Family LIPARIDIDÆ

## TRISMEGISTUS OWSTONI Jordan and Snyder, new genus and species

(PLATE LVIII AND FIGURE 29)

The new genus *Trismegistus* differs from *Liparis* in having the skin rough with prickles, with broad, rounded bases, like thumb-tacks. Size over-large for a Liparid.



FIG. 29.—*Trismegistus owstoni* Jordan and Snyder. (Section of the epidermis, from the under side, showing the peculiar prickles.)

The species is known from a single specimen 11 inches long. The species according to Mr. Owston is quite unknown to Japanese fishermen. It resembles *L. agassizii* Putnam, differing in the generic character of small epidermal plates or shields. Type No. 8385, Ichthyological collection, Leland Stanford Junior University, from Enoshima, Sagami bay, Japan. Length 44 cm.

Head  $4\frac{2}{3}$  in length, measured to base of caudal fin; depth 4; eye 11 in length of head; snout  $2\frac{1}{3}$ ; width of mouth  $1\frac{1}{2}$ ; width of interorbital space  $1\frac{3}{4}$ ; dorsal 43; anal 36; pectoral 40; caudal 10.

Interorbital space slightly convex. Anterior nostril with a low rim. Jaws covered with bands of minute, trilobed teeth; upper and lower pharyngeals with small pads of villiform teeth. Width of gill opening contained  $2\frac{1}{3}$  times in the length of head, projecting about half its width below upper edge of pectoral fin; gill-rakers  $1 + 7$ , small and stubby; covered with horny setæ; filaments of pseudobranchiæ about one-third as long as those of the gills.

Origin of dorsal on a vertical passing through a point about twice the diameter of eye behind base of pectoral; origin of anal below eighth dorsal spine; anterior portions of both dorsal and anal covered with thick skin and gelatinous tissue; both fins united with the caudal, the dorsal extending to within an eye's diameter of the tip of the latter; anal reaching vertical through tip of caudal. Caudal slightly convex posteriorly. In *L. agassizii* the dorsal and anal do not quite reach the middle of caudal; the dorsal is partly separated from the caudal by a notch; the caudal is rounded posteriorly. Pectoral rounded, with 40 rays (34 or 35 in *Liparis agassizii*), none of the lower rays longer than those above them; lowermost rays fleshy, their tips separated as in *L. agassizii*. Pads of ventral disk soft; edge of disk very thin; longitudinal diameter contained  $2\frac{1}{5}$  times in the length of head, a little less than distance between disk and anal opening.

Skin loose, the surface with very small irregular folds, on which are minute plates or shields resembling thumb-tacks in shape, the spicule pointing outward, the round flat head imbedded in the epidermis (figure 29). Lips, chin, throat, axil, and belly apparently without the plates. No barbels on head. Snout with 10 large pores in a transverse row above mouth.

Color pale gray, clouded with dark gray and black; a row of small, blackish clouds along base of dorsal; a second row of larger, black clouds below the latter; body near base of anal blackish; dorsal, anal, caudal blackish, especially along the edges; pectoral dark gray on the outer portions, blackish along edges; under or posterior side of fin darker than the outer.

#### Family ATELEOPIDÆ

#### ATELEOPUS JAPONICUS Schlegel

Three fine specimens, the one from off Izu, the others from off Kozu in Sagami bay.

“Several were taken on the Mirsukurina bank at Kozu. One was caught in Tokyo bay where it was doubtless out of its depth.”

## Family TRACHYPTERIDÆ

## TRACHYPTERUS ISHIKAWÆ Jordan and Snyder

*(Trachypterus ijimæ* Jordan and Snyder; young)

(PLATE LXIII)

Two specimens about 172 centimeters long were "taken at the surface in a dying state off Mera on the west coast of Bashu, near the mouth of Tokyo bay."

*Trachypterus ijimæ* is probably an example of the young of this species, the type specimen of which had about 198 dorsal rays.

Head 8 in length, depth  $7\frac{3}{4}$ , dorsal 168, pectoral 9. Length of head somewhat greater than its depth, the latter equal to distance between tip of snout and posterior border of eye; snout  $2\frac{1}{3}$  in head; eye  $3\frac{1}{2}$ ,  $3\frac{2}{3}$  in depth of body; width of interorbital space  $1\frac{3}{5}$  in diameter of eye; lower jaw projecting slightly beyond the upper; process of premaxillary extending to a vertical through posterior border of eye; maxillary with a leaf-shaped flap a little longer than diameter of eye, with branched striations extending outward from its point of attachment; opercular bones with conspicuous striations. Teeth very weak; 2 or 3 small, loosely imbedded ones on vomer, a row of 4 on the premaxillary, 3 or 4 on each side of symphysis of lower jaw. Gill-rakers on first arch  $5 + 11$ , provided with tooth-like setæ on the inside; filaments of pseudobranchiæ equal in length to those of the gills.

Origin of dorsal above upper edge of gill opening, the rays highest near beginning of posterior third of body, where they are about  $1\frac{1}{3}$  times the diameter of orbit. Length of pectoral equal to diameter of orbit. Ventral fins absent or represented by a mere filament, the place of insertion indicated by a narrow groove below posterior edge of base of pectoral. Caudal projecting upward; filaments absent, possibly broken. Several small spines projecting downward and backward from end of caudal peduncle.

Head naked; body closely covered with minute pads or plates containing a varying amount of bony matter; those on median part of the ventral surface pointed, hard and white like enamel; along dorsal part of body enlarged plates are arranged in vertical rows parallel with the interneurals. Lateral line with large, quill-like tubes, beginning at upper edge of gill opening, gently bending downward and extending along body somewhat below the median line; armed near caudal fin with a few weak spines.

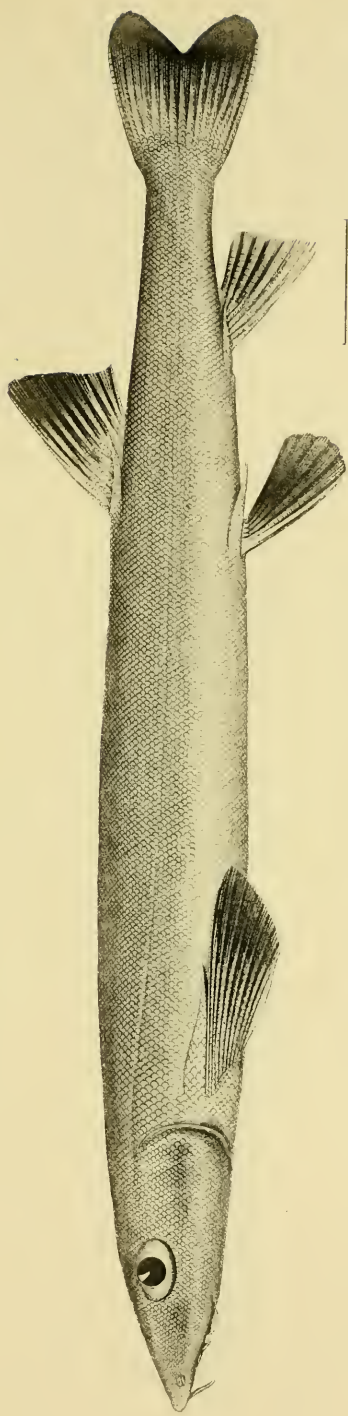
Color dusky, ventral surface and a narrow area along base of dorsal darker.



TRISMEGISTUS OWSTONI JORDAN AND SNYDER.

(Drawn by W. S. Atkinson)





GONORHYNCHUS ABBREVIATUS SCHLEGEL.

(Drawn by W. S. Atkinson.)



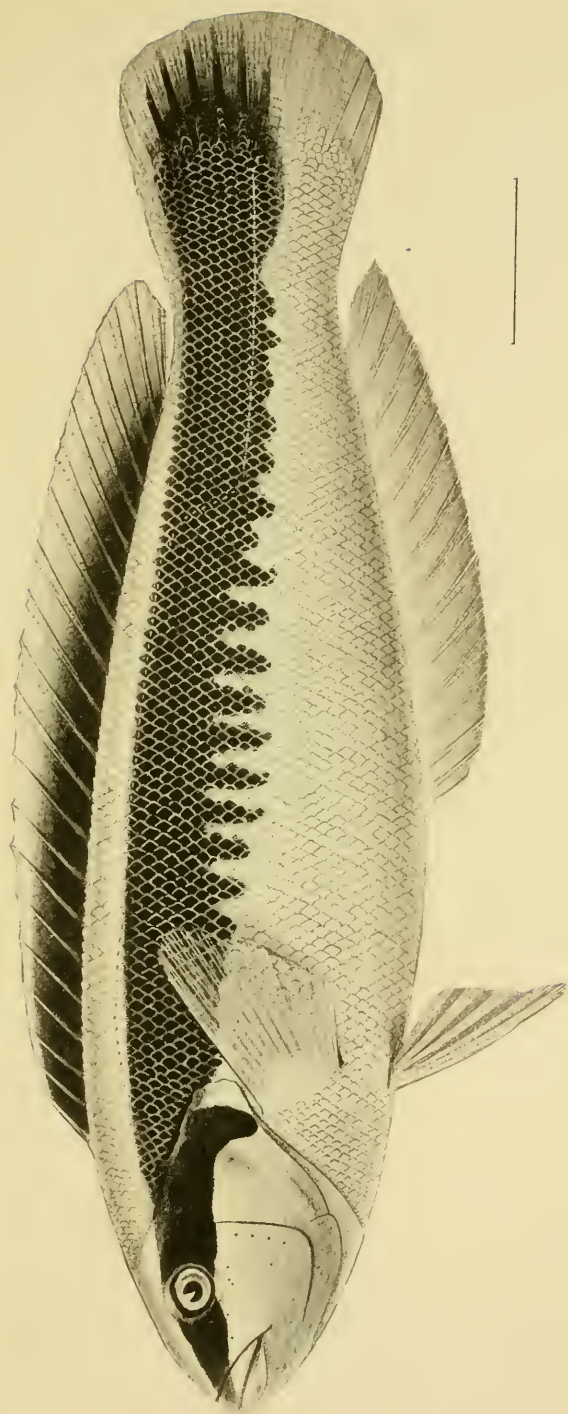




PRISTIURUS EASTMANI JORDAN AND SNYDER.

(Drawn by W. S. Atkinson)





JULIUS MUSUME JORDAN AND SNYDER.

(Drawn by W. S. Atkinson)



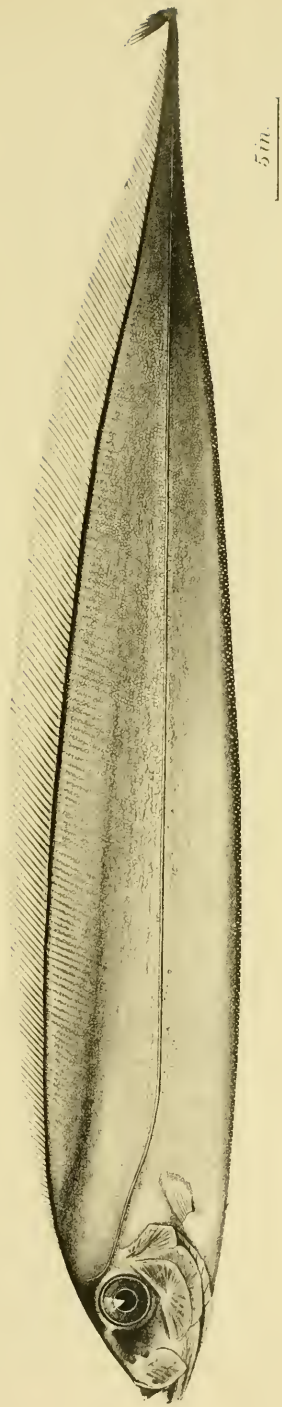


1

PSEUDOTRIAKIS ACRALES JORDAN AND SNYDER.

(Drawn by W. S. Atkinson)





TRACHYPTERUS ISHIKAWÆ JORDAN AND SNYDER,  
(Drawn by W. S. Atkinson)





DESCRIPTION OF A NEW CYPRINOID FISH, HEMI-  
BARBUS JOITENI, FROM THE PEI HO,  
TIENTSIN, CHINA

By DAVID STARR JORDAN AND EDWIN CHAPIN STARKS

A collection of fishes from the Pei Ho at Tientsin, China, made by Prof. Noah Fields Drake, of the University of Tientsin, was sent in 1898 to the Museum of Leland Stanford Junior University. These fishes were studied by Mr. James Francis Abbott, and a report published by him in the *Proceedings* of the U. S. National Museum, vol. XXIII, 1901. The specimens called by Abbott (p. 487) *Hemibarbus barbuis*, seem distinct from the Japanese species of that name. We propose for them the new specific name—

**HEMIBARBUS JOITENI** Jordan and Starks, new species

(PLATE LXIV)

Head 4 in length to base of caudal; depth  $4\frac{1}{8}$ . Dorsal III, 7 (the last ray divided to its base); anal 8; lateral line scales 48.

Body rather robust; a slight hump developed at nuchal region. Snout rather sharp as viewed laterally; projecting beyond mouth a distance slightly exceeding half the diameter of eye. Lips thick and papillose in large specimens; lower lip with a backward projecting median flap. Length of maxillary barbel is from half to two-thirds of the diameter of the eye. Teeth in three rows; the outer row large; the two inner rows small; the first with five teeth, the second three, and the inner row with one. Anterior nostril ending behind in a broad flap which nearly closes posterior nostril. Large sensory canals follow the lower edge of the suborbitals and the edge of the preopercle, extending around the under side of the snout and mandible; they open to the exterior at rather wide intervals along their length through very small pores. Interorbital space rather wide, from  $1\frac{1}{2}$  times diameter of eye in small specimens to nearly 2 in large ones; in the latter 3 slight longitudinal ridges are developed; a median ridge and a ridge at each side between outer edges of frontals and supraorbitals. There are  $7\frac{1}{2}$  scales in the backward downward series from first dorsal spine to lateral line and  $6\frac{1}{2}$  in a like series from front of anal to lateral

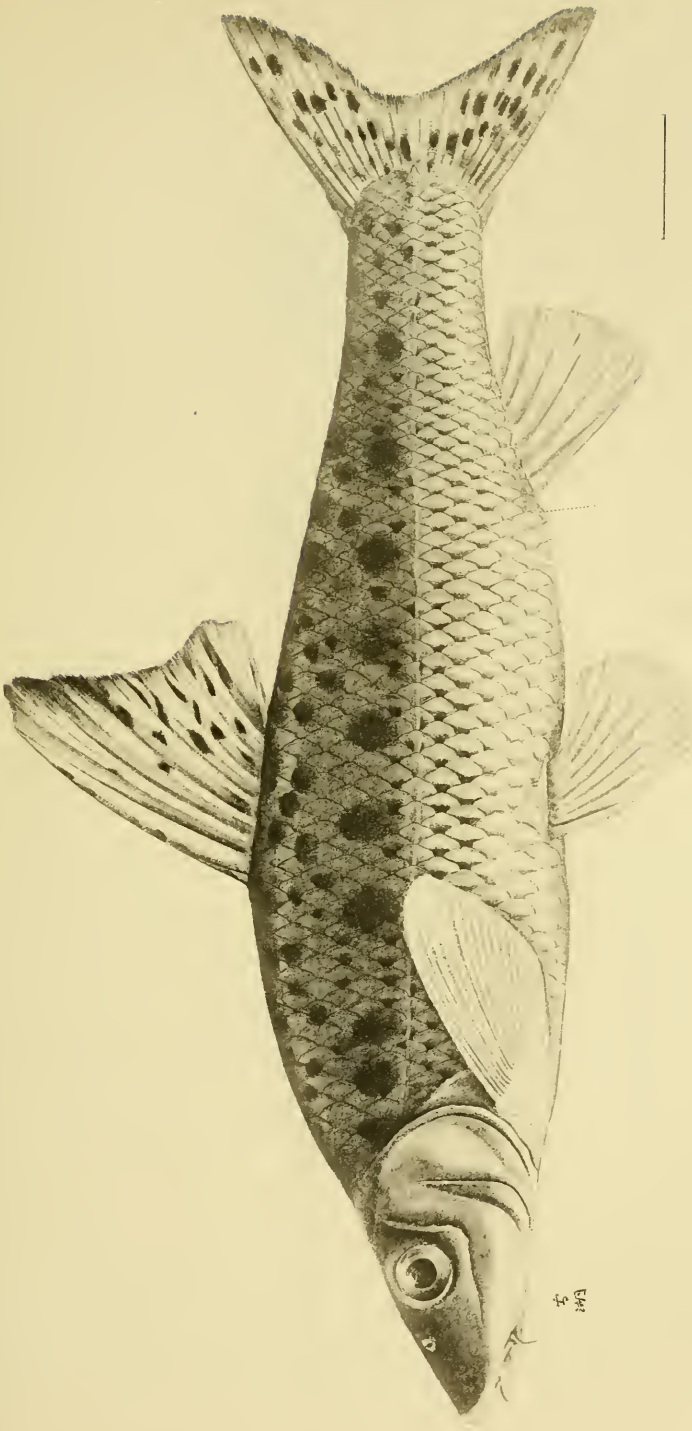
line; 16 scales in a median line between first dorsal spine and nape. Scales of lateral line slightly indented on their posterior edge; many of the scales on back with a slight angle, others with a slightly produced scallop. First dorsal spine very small, the second a fourth as long as the third, which is contained from 1 to  $1\frac{1}{8}$  in length of head. Front of dorsal midway between snout and a point on caudal peduncle distant from base of caudal fin once and a half times diameter of orbit. Pectoral fails to reach vertical from front of dorsal by a distance equal to half the diameter of the eye.

Color in spirits pinkish yellow with a longitudinal lateral series of about 8 large black spots above lateral line; smaller spots irregularly placed on back and sides (on the large specimens following the rows of scales); dorsal and caudal with similar black spots; other fins without markings.

This species differs from *H. barbatus*, particularly in color. The black spots have been seen only in the young of the latter species.

Four specimens collected by Dr. Drake in the Pei Ho at Tientsin, China. The largest, No. 8414, Stanford University, is 29 cm. in length.

The species is named for the enlightened and progressive Emperor of China, officially known as Kwang-Hsu, Joi-Ten being his personal name, not spoken by Chinamen but available in the democracy of science.



HEMIBARBUS JOITENI JORDAN AND STARKS.

(From Pei Ho River, Tientsin, China. Collected by Noah F. Drake. Drawn by Sekko Shimada)





*James Smithson*

THE REMOVAL OF THE REMAINS OF  
JAMES SMITHSON

By S. P. LANGLEY

The remains of James Smithson, founder of the Smithsonian Institution, who died June 27, 1829, at Genoa, Italy, were deposited in the little cemetery belonging to the English Church, on the Heights of San Benigno, a solitary spot planted with cypress trees, and looking down upon the Gulf of Genoa. In 1891 the Secretary of the Institution visited the grave, and, with the approval of the Regents, deposited with the Secretary of the English Church Fund a small sum to invest in Italian five-percent rentes, for its perpetual care. It was visited on two later occasions by the Secretary, who placed a bronze tablet containing a bas-relief of Smithson, in the English Church, and one also at the tomb, whence it was subsequently stolen.

At this time it was understood that there was a probability that before many years the site of the cemetery might be required by the Italian authorities, and the following communication to this effect was made to the Secretary on the 24th of November, 1900, by the Committee of the British Burial Ground:

7 VIA GARIBALDI, GENOA,

24 November, 1900.

SAMUEL PIERPONT LANGLEY, Esq., LL.D., D.C.L.,

Smithsonian Institution, Washington.

*Dear Sir:*

The Committee of the British Burial Ground of Genoa (of which you are aware Her Majesty's Consul is Chairman), fully realizing how keenly you are interested in all that concerns the resting place of the respected Founder of your Institution, has deputed me to write to you and lay before you the present position of our Cemetery.

It will lie in your recollection that when I accompanied you some years ago up to the heights of San Benigno, you were struck by the enormous quarry which was slowly but surely eating its way towards us from the sea through the rocky side of the hill on which we stand, and excavation has lately come so close to us that the intervention of the Consul became necessary to arrest further advance on the plea that our property would be endangered if the quarrying were carried on.

Actual blasting has in fact been put an end to for the present, and the Cemetery (although the boundary wall is now on the very edge of the excavation) remains untouched; but the local authorities who are the owners of the quarry have given us to understand that they need more stone for their harbor works, and are therefore anxious to see our graves transferred from the position they now occupy, for which purpose they would give us a suitable piece of ground in another part of the town and would also undertake the due and fitting transport of the remains. Should our answer be in the negative, it is intimated to us that in five years' time, in 1905, the term for applying the Law for Public Utility (twenty years after the date of the last burial) will have been reached, and we shall then have to give up of necessity what we are now asked to yield as a concession.

Under the circumstances, the Committee have decided that it is their best policy, in the interest of all concerned, to begin to negotiate at once for the transfer on a decorous footing of the British Cemetery and all its tombs, and although some considerable time may elapse before this transfer is accomplished, yet it is evident that the time has now come for us to ask you to prepare your decision as to what is to be done with regard to the James Smithson remains. Are they to be laid with all possible care and reverence in new ground here, or are they to be conveyed to the United States?

Awaiting the pleasure of your reply, I beg to remain,

Very faithfully yours,

E. A. LE MESURIER.

This communication was laid before the Regents, who, at their meeting of January 23, 1901, adopted the following resolution:

RESOLVED: In view of the proposed abolition of the English Cemetery at Genoa which contains the remains of James Smithson,

that the Secretary be requested to arrange either with the English Church or with the authorities of the National Burying Ground at Genoa for the re-interment of Smithson's remains, and the transfer of the original monument.

At a meeting of the Regents held on the 22d of January, 1902, the Secretary recalled to the Board the resolution adopted at its previous meeting, and stated that the wishes of the Board with regard to the removal of the remains of Smithson had been communicated to Mr. E. A. Le Mesurier, one of the officers of the English Church at Genoa, who, under date of December 23, 1901, had replied in part as follows :

You are aware that our hope is eventually to obtain for our countrymen a separate burying-place which by an easy, and I may say obvious, arrangement might be made to give shelter not merely to British subjects but to American also. I regret to say, however, that I see no chance for the present of this most desirable consummation, as the authorities (apparently in consequence of the difficulty of finding an alternative site) have withdrawn their offer of providing us with a fresh cemetery if we allowed them to transfer at once all remains from San Benigno, where your Founder rests. The present policy of the authorities is presumably to let things remain as they are until the time comes (three years or so hence) when the Law of Public Utility will strengthen their hands as to taking possession of the San Benigno ground, of course under the obligation of transporting the remains elsewhere, which would in all probability mean a portion of the general Protestant cemetery and not a separate place of interment. When the time for the transfer approaches, it will be obviously expedient to apply to the British Ambassador at Rome (backed up, as we are confident will be the case, by the friendly offices of the Representative of the United States) to put the case before the Italian Government, so that the local authorities may be enjoined to carry out the process with all due reverence, and if possible (as it ought to be possible) to a especially reserved new Cemetery. Our Consul is most fully alive to the importance of diplomatic support and will take the initiative in due course.

Doctor A. Graham Bell, a member of the Board, took occasion to reiterate the strong feeling expressed by him at the preceding meeting of the Regents, that the remains of Smithson should be brought to this country.

At the regular meeting of the Regents held on December 8, 1903, the Secretary read the following letter from the United States Consul at Genoa, and that from the Committee of the British Burial Ground Fund in Genoa :

## CONSULAR SERVICE, U. S. A.

GENOA, ITALY, November 24th, 1903.

DR. S. P. LANGLEY,  
Secretary of the Smithsonian Institution,  
Washington, D. C.

*Dear Sir:*

Referring to my letter of June 30th last, I now forward enclosed circular letter just received, which shows that the final step in the demolition of the old British Cemetery is about to be taken. If you have any desires to express as to the disposition of the remains of James Smithson, and instructions to give, these should be made known with as little delay as possible.

You will see by my letter above mentioned that there is a tradition here of some opposition to the removal of James Smithson's body to America on the part of relatives in Europe. I was informed at the British Consulate that the source and character of this opposition has been made known at some time to the Smithsonian Institution. I can learn nothing further of it here. You are therefore in possession of such information as can be had for your guidance in adopting a course of action as to the disposition of the remains. You will notice that instructions are requested by the Cemetery Committee before January 1st, 1904.

I am quite at your service in the matter of any assistance that may be needed here.

I am informed by the Agent of the American Express Company here, he would transport the body to Washington for \$203. This would not include taking up the body nor the coffin, the boxing, etc. A Government tax of 360 lire (approximately \$72.00) has also to be paid on every body taken out of the country. The total expense at a rough estimate might come to \$400.00 or to \$500.00 if something unusually handsome in the way of a casket were called for. All due economy would be used.

Believe me

Very truly yours,

WILLIAM HENRY BISHOP,  
*U. S. Consul.*

(*Enclosure*)

GENOA, November 23, 1903.

*Sir,*

We have the honor to inform you that the old British Cemetery, on the heights of San Benigno in this city, has been expropriated by the Italian authorities, and will shortly be demolished.

The remains of all persons buried there will be removed to the new British Cemetery at public expense, and the tombstones will also be removed, and re-erected over the new graves, by the undersigned Committee, unless otherwise desired by the representatives of the deceased.

It has been impossible to ascertain the addresses of these representatives in every case, and this letter is sent to you with reference to the grave of James Smithson.



Kindly address any communication you may wish to make on this matter to

NOEL LEES Esq.,  
*Care of H. B. M.'s Consul-General—Genoa*

before January 1st, 1904.  
 And believe us,  
 Yours faithfully

THE COMMITTEE  
 BRITISH BURIAL GROUND FUND  
 Genoa.

Doctor Bell renewed the proposal made by him at the previous meeting of the Regents, that the remains of Smithson be brought to this country at his expense, and after some remarks the following resolutions were adopted:

RESOLVED: That Doctor A. Graham Bell be appointed as a committee to take charge of the matter of the removal of the remains of James Smithson from Genoa to Washington, with the request that the negotiations and removal be conducted quietly and privately.

RESOLVED: That upon the conclusion of this duty, all expenses involved by it be reimbursed to Doctor Bell from the funds of the Institution.

Doctor Bell, accompanied by Mrs. Bell, sailed on the 15th of December for the port of Cherbourg in France, and going thence to Genoa, commenced at once the arrangements for the transfer of the remains, arrangements which would have occupied a quite indefinite time and incurred a corresponding delay, except for the aid given by the United States Consul, Mr. William Henry Bishop, which Doctor Bell gladly acknowledges.

On opening the tomb in the presence of Mr. Bell, the United States Consul, Noel Lees, Esq. (official representative of the British Burial Ground Fund Association), and other witnesses, it was found that the remains of Smithson, represented by the skeleton, were in fair preservation, although the wooden coffin in which they had been enclosed had molded away. The remains were placed in a metal casket and deposited in the mortuary chapel of the cemetery, where they rested until January 2, when the casket was enclosed in a coffin of strong wood and covered with the American flag by Consul Bishop. On this occasion Doctor Bell, Mr. Bishop, and the other witnesses again assembled, and the following remarks were made:

*Remarks by William Henry Bishop, Esq., United States Consul.*

DOCTOR ALEXANDER GRAHAM BELL: You arrived here, my dear Dr. Graham Bell, charged by the Smithsonian Institution with the

mission of removing to Washington the remains of the Founder of that Institution, James Smithson, who has been buried till now in the cemetery where we stand, since his death, at Genoa, in the year 1829. Having been invited by you and by the Smithsonian Institution to aid you, to what extent I might be able, in this object, it has been a matter of great pride and pleasure to me that I have been allowed to do so.

All the steps necessary to such removal have now been taken. We have received the authorization of the governmental heads of the Province, the City, and the British Burial Ground Fund, in which latter the title to the cemetery and the custody of the grave of James Smithson are vested, and all of these have kindly coöperated with us in the work.

The body of James Smithson has now been reverently raised from the earth; it has been placed in a case securely sealed, and this case stands ready to pass into the charge of the Steamship Company which will convey it to New York.

I assure you that it is with a feeling of real emotion that I have just now cast the American flag over the body of this illustrious man, this noble but as yet little known benefactor, as it is on the verge of beginning its journey to the United States. The flag adopts him already, as it were, in the substance, for our country, to which he has so long belonged in the spirit. He is now about to receive there a portion of the outward veneration and homage he so supremely merits, and which, owing to the modest circumstances of his life, and his interment here in some sense almost forgotten, he has never had.

Shall I admit that on taking possession of my post as Consul at Genoa, I did not even know who James Smithson was? I may say that I was surprised to learn that he was buried at Genoa; more surprised still that he was an Englishman, who had never even set foot in America. He left his great bequest to the United States, then in its infancy, through admiring confidence in our future. It is likely that many, or even most, Americans are in the same condition as was I myself; for occasion has rarely arisen for taking thought as to the personality of the man. Happily this unenlightened condition of mind is about to cease.

Dr. Graham Bell, I wish you a hearty God-speed across the ocean, with your precious freight. The American people will receive it with general gratification, and, through the Smithsonian Institution, will soon delight to pay it great honor.

*Response by Doctor Alexander Graham Bell.*

MR. CONSUL: It is with feelings of deep emotion that I undertake the transportation of the remains of James Smithson from the cemetery where they have so long reposed, to their last resting place in the United States.

On behalf of the Smithsonian Institution allow me to thank you, Mr. Consul, for the unwearied zeal and care with which you have given me your assistance. Without your active coöperation—and

without your personal sympathy—it would have been difficult indeed for me to have accomplished the object of my mission here.

On behalf of the Smithsonian Institution, I beg to thank you too—Mr. Noel Lees—for your courtesy and attention; and trust that you will convey to His British Majesty's Consul General, and to the Committee of the British Church Burial Ground Fund, my thanks, and the thanks of the Institution I represent, for their ready assistance in furthering my mission.

The United States of America will provide in Washington, D. C., a suitable and permanent resting place for the remains of her great benefactor, James Smithson, through the instrumentality of the Smithsonian Institution—the Establishment created by the Government to perpetuate his name.

*Remarks by Noel Lees, Esq.*

DOCTOR GRAHAM BELL: I beg to thank you heartily for the words you have said with regard to the aid you have received from the Burial Board and myself. Although we regret to lose the remains of James Smithson, we at the same time feel that in the country to which he left his money, with such charitable intent, his remains will receive the honor and glory which have so long been due to them, and we must understand that our loss is America's gain. To us it will always remain a pleasant memory that, from the date of his burial to the present day, we have had in our custody in this picturesque little church-yard, the remains of a man whose foresight and kindness have enabled so many in the New World to benefit.

On the conclusion of these remarks the remains were placed on board the steamer *Princess Irene* of the North German Lloyd line, which brought them to New York, where they arrived on the night of January 19, in the continued charge of Doctor Bell, the vessel reaching her dock at Hoboken early on the morning of the 20th. By direction of the President of the United States, the U. S. steamer *Dolphin* had been detached to meet the *Princess Irene* in the lower bay and to accompany her up the harbor, while a tug belonging to the Navy Yard attended at the dock to receive the remains and transport them to the *Dolphin*. They were received by Mr. Bell and the Secretary of the Institution, Mr. Bell accompanying the remains to the *Dolphin* and taking passage on her himself for Washington, where she arrived at the Navy Yard on Saturday the 23d.

On Monday the 25th the remains were transported by the Naval authorities, with suitable ceremonies, to the Navy Yard gate, where they were taken in charge by a cavalry escort furnished by the War Department, and, accompanied by Assistant Secretary of State Loomis, representing the President, by the British Ambassador, the Regents and the Secretary of the Institution, and the

President of the Board of Commissioners of the District of Columbia, they were conveyed to the Smithsonian Institution, where the coffin, draped in the American and British flags, was deposited in the center of the Main Hall of the building.

Dr. Alexander Graham Bell, addressing Senator Frye in behalf of the Regents, said:

MR. SENATOR: I have the honor to hand over to the Smithsonian Institution the mortal remains of its founder, James Smithson, a Fellow of the Royal Society of London, England, who died in Genoa, Italy, on the 27th of June, 1829.

For nearly seventy-five years the body of Smithson has reposed in an almost forgotten grave in the picturesque little British cemetery on the heights of San Beningo in Genoa. City improvements have led to the expropriation of this cemetery and the removal of the remains, and at the last meeting of the Board of Regents of the Smithsonian Institution I was appointed a committee to arrange for the transfer of the remains of Smithson to this country. On my arrival in Genoa, every facility was afforded me for the accomplishment of my mission by the provincial and municipal authorities, by His British Majesty's Consul-General, Mr. Keene; by the Committee of the British Burial Fund Association, in which is vested the ownership of the cemetery, as well as by our own Consul, Mr. William Henry Bishop, to whom I am much indebted for his valued services.

On the 31st of December, 1903, the tomb of Smithson was opened in my presence, as the representative of the Smithsonian Institution, and in the presence of the American Consul and six other witnesses. The remains of Smithson were reverently raised from the grave and placed in a metallic casket, over which the Consul of the United States cast the American flag while the witnesses stood around with uncovered heads. The casket was then left in the mortuary chapel of the cemetery, securely sealed and under guard, until the 2d of January, when it was placed in a coffin of strong wood, as demanded by Italian law, and was then transported to the North German Lloyd steamship *Princess Irene*, accompanied by the American Consul and myself.

The steamer sailed from Genoa on the 7th of January, and upon arrival in the United States, the remains of Smithson were received with national honors by direction of the President, and of the Secretary of the Navy and the Secretary of War.

The remains were brought to Washington on board the United States dispatch boat *Dolphin*, and have been escorted to the Smithsonian Institution by United States cavalry.

And now, Mr. Senator, my mission is ended, and I deliver into your hands, as the representative of the Board of Regents of the Smithsonian Institution, the remains of this great benefactor of the United States.

Senator Frye replied :

SIR, the Smithsonian Institution receives with profound gratitude the remains of its distinguished founder. Providence, every now and then, seems to place in the world a man and inspires him with a purpose to elevate his fellow men. Such a man was Mr. Smithson, the founder of this Institution. The spirit, Sir, which prompted you to such earnest endeavor, resulting as it did in taking these remains from their resting place in a country foreign to him and foreign to us, and bringing them here where for so many years we have enjoyed the rich fruits of his splendid benefaction, your countrymen will appreciate. His grave here will be an incentive to earnest, faithful, wise, and discreet endeavor to carry out his lofty purposes, and, Sir, it will be to our people a sacred spot while the Republic endures.

The brief but impressive ceremonies of the occasion concluded with the following prayer, offered by the Reverend Doctor Randolph H. McKim :

Almighty God, eternal source of light and truth, by whose wise providence all things in heaven and earth are governed, we give Thee thanks that Thou didst put into the heart of Thy servant whose dust we receive with reverence here to-day, to lay the foundation of this school of science, and we pray Thee that it may more and more be instrumental in the true interpretation of the laws of nature, and in unveiling to the mind of man the glory of God in the work of His hands, to the end that for all the generations to come, this Institution may be a beacon light of truth and of progress, to the glory of God and to the good of mankind. All this we beg through Him by whom all things were made, Jesus Christ, our Lord. Amen.

The remains rest temporarily in a room which contains the few personal relics of Smithson, until their final disposal by the Regents.

## NOTES ON THE BREEDING HABITS OF THE YELLOW-BELLIED TERRAPIN

BY HUGH M. SMITH

In the Potomac river between Washington and salt water, the yellow-bellied terrapin (*Pseudemys rugosa*) in former years supported a profitable fishery, but for a long time it has been uncommon and is now seldom sought, those caught being taken incidentally in winter seines hauled for fish. The decline of the fishery, while due primarily to the decrease in abundance of the terrapin, was to a considerable extent dependent on the establishment in Washington and other eastern cities of a trade in southern and western terrapins which could be caught in large numbers and sold at much lower prices than the local species. The terrapins frequented the marshy shores and heads of creeks, and were caught with haul seines and fyke nets during fall and winter. Piscataway creek was one of the best fishing grounds, and many hundreds of dozens of terrapin were taken there every winter for the Washington market. On one day in December, about the year 1883, 240 terrapin were there caught at one seine haul by Mr. L. G. Harron, now of the U. S. Bureau of Fisheries; they had been buried on a shallow bar, but had uncovered themselves under the influence of an unusually warm spell. The largest were sold for seventy-five cents apiece in Washington, which was about the average price in those days, while the smallest, six to seven inches long, were worth only fifteen or twenty cents. This species is known along the Potomac under the names "slider," "terrapin," and "fresh-water pullet," the last designation being in common use among fishermen and negroes generally.

The egg-laying season is in June and July, and the place where the eggs are laid is usually a cultivated tract, often a cornfield adjoining the water. It is probable that a field would always be selected, but when there is a high steep bank the eggs are of necessity deposited on the shore. The terrapins visit the fields only during egg-laying time and only for this purpose, and sometimes make their nests more than one hundred feet from the water. It has often been observed that six or eight terrapins will lay on the same shore or in the same field, their tracks being easily discernible in the moist or soft sand or loam. The nest is made in

sand, clay, or loam, a sandy loam or sandy clay being most frequently chosen. The nest, which is shaped like a carafe, is dug by the female with her fore-legs. Its size depends on the size of the animal or, what amounts to the same thing, on the number of eggs to be laid; an average nest would be four inches deep and four inches wide at the bottom, the opening being somewhat smaller than a silver dollar. When on the shore, the nest is always above high-water mark.

All the eggs are laid at one time, and when the laying is completed, earth is scraped into and over the hole and packed tightly. The packing is accomplished by the terrapin raising herself as high as possible on all four legs and then dropping heavily, by the sudden relaxation of the extensor muscles. Immediately after covering the nest, the terrapin withdraws to the water.

The size of the eggs varies somewhat with the size of the terrapin, but averages one inch by three-fourths of an inch. A six-inch terrapin lays ten or twelve eggs, while the largest terrapins, fourteen or sixteen inches long, lay as many as twenty-five to thirty-five eggs, possibly more. When a terrapin is disturbed while making a nest or laying, she will abandon the nest. On one occasion, when a terrapin was discovered over a nest in a cornfield, removed to see whether any eggs had been deposited, and replaced over the hole in the ground, it was found when the place was visited two hours later that she had left without laying any eggs. The eggs probably hatch during the summer, but on this point there have been no personal observations. The young, however, remain in the nest until the following spring (April 10 in one case), and when they emerge they are about the size of a twenty-five-cent piece. They go to the water at once.

Considerable quantities of terrapin eggs were formerly eaten by people living on the river shores, but of late very few eggs have been thus utilized. When boiled, the eggs are regarded as a delicacy. Birds (especially crows) and other animals doubtless destroy some eggs. On one occasion a terrapin was observed over a nest on the shore, and a crow noticed on a dead tree near by. When the terrapin covered the eggs, concealed the nest, and withdrew to the water, the crow immediately dropped to the ground and began to dig into the nest. Before the observer, who was in a boat, could reach the shore, the crow had destroyed at least two of the eggs, seven others remaining.

The male yellow-bellied terrapin is smaller than the female; his claws are twice as long as hers, and the under-shell is flat, while in the female it bulges centrally.

## A NEW PELICAN FISH FROM THE PACIFIC

By BARTON A. BEAN

During a morning watch in June, 1900, half-way between Midway islands and Guam, on the U. S. Naval Ship *Nero*, there was brought to the surface what is believed to be the first pelican fish recorded from the Pacific ocean. The specimen was entangled on the sounding wire, near the sinker, the depth of the ocean at the point of capture being between 2000 and 3000 fathoms. The steamer was engaged at the time in a survey for the Transpacific telegraph cable, and it was during this voyage that the greatest depth of water ever recorded was discovered, being 5269 fathoms, in  $12^{\circ} 43' 15''$  N. lat.;  $145^{\circ} 49' 00''$  W. long.

### GASTROSTOMUS PACIFICUS new species

Length of preserved portion  $14\frac{1}{2}$  inches (tail end of body wanting); length of cranium  $\frac{9}{16}$  of an inch, equal to its width; length of upper jaw  $3\frac{3}{4}$  inches; distance from tip of snout to origin of dorsal fin a little more than  $\frac{2}{3}$  length of upper jaw; the depth of body at angle of jaws is about  $\frac{1}{3}$  of the length of upper jaw; the gill slit is under the 12th dorsal ray; the first anal ray is under the 34th dorsal ray. Dorsal and anal rays high, the highest about  $\frac{1}{6}$  length of upper jaw.

This species differs from *Gastrostomus bairdii* Gill, the Atlantic form, in having a more robust body and higher fin rays. The single specimen known is badly mutilated, and better material, should other captures of the fish be made, will doubtless show many points of difference from the Atlantic species. We are indebted to Dr. J. M. Flint, U.S.N. (retired), for assistance in obtaining the records of this interesting capture.

The type is No. 50,724, U. S. National Museum. The accompanying illustration (figure 31) was made by Mr. A. H. Baldwin.



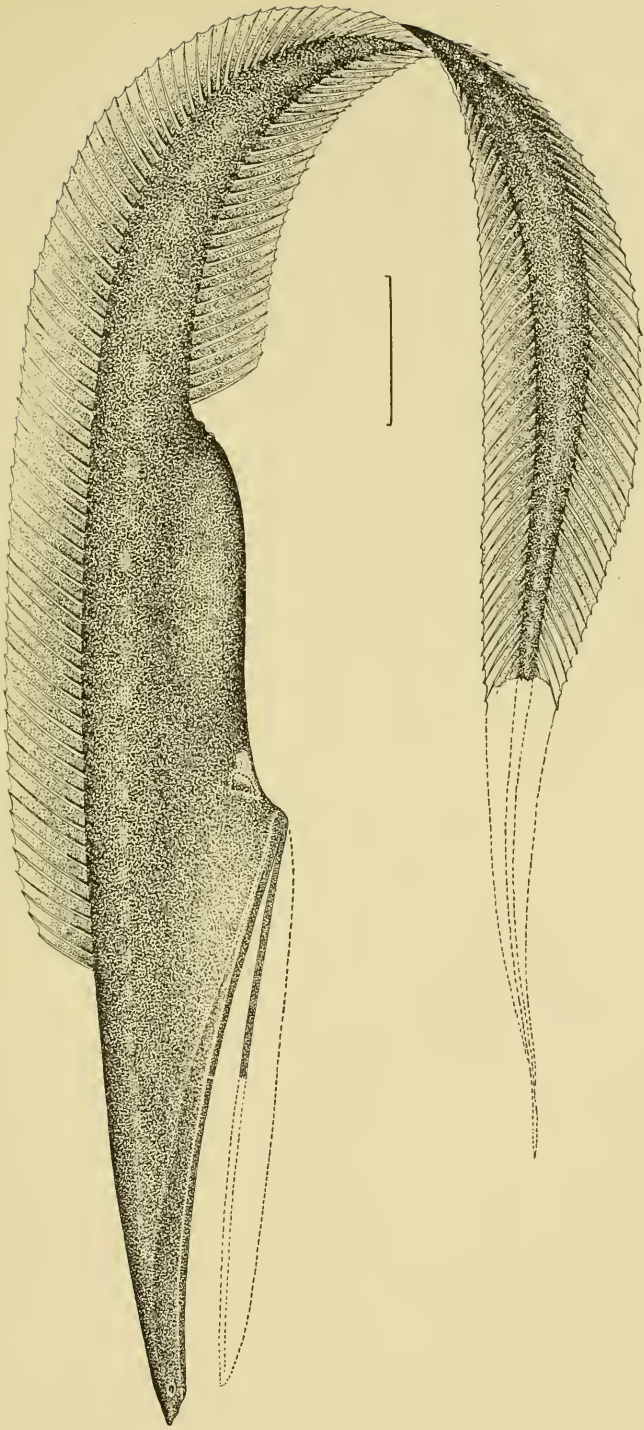


FIG. 31.—*Gastrostomus pacificus* type B. A. Bean. (Restored.) U. S. Naval Ship *Nero*, June, 1900. Halfway between Midway islands and Guam.

# A REVISION OF THE PALEOZOIC BRYOZOA

BY E. O. ULRICH AND R. S. BASSLER

## PART I.—ON GENERA AND SPECIES OF CTENOSTOMATA

In 1897 Mr. Ulrich undertook the preparation of as complete a collection as possible of American fossil Bryozoa for the British Museum of Natural History. At the same time the late Professor Zittel of Munich wished a similar although somewhat smaller collection for his university. The junior author was at that time assisting Mr. Ulrich, so the two decided, while preparing these collections, to revise especially the generic and specific classification of the Paleozoic Bryozoa, as thoroughly as the material at hand would permit. With the exception of two short trips into the field, Mr. Ulrich spent two years in the preparation and study of thin sections and the separation of large collections embracing representative examples of the whole class. Mr. Bassler, besides aiding Mr. Ulrich in this work, also undertook the review of all the literature of Paleozoic Bryozoa and the compilation of a card catalogue of the American forms, using as a basis a list and bibliography prepared some years before by Mr. Ulrich. In 1900, Mr. Bassler, collaborating with Mr. John M. Nickles, who had prepared a similar card catalogue, published<sup>1</sup> much of the information concerning genera and all of the synonymy learned during the preparation of these collections and catalogues.

During the course of our studies, particularly of the *Trepodomata*, some four or five thousand thin sections were prepared. Of many species we made sometimes as many as a dozen sets of sections to determine the specific variation. Naturally the immense quantity of material studied afforded many new species, and these, besides aiding the strict characterization of the previously established generic groups, also served in distinguishing certain new genera that previously had been known only from species more or less imperfectly understood and therefore difficult to classify satisfactorily. At the same time a number of wholly new genera were determined, while other, perhaps equally distinct, groups require further material to prove the permanence of their peculiarities.

<sup>1</sup> *Bulletin 173, U. S. Geological Survey.*

As to the new species, they are to be numbered by the hundreds. This is indicated by the junior author's recent paper on *Homotrypa*,<sup>1</sup> in which the number of the Cincinnatian species of the genus previously described is more than trebled. While the specific representation of this genus of the *Trepotomata* is exceptional, it is still true that many of the other genera are very prolific in species and will continue to afford subjects for papers on new forms for years to come.

This and the following papers of this series are based almost entirely on the collection in the U. S. National Museum, which consists mainly of the recently-acquired Ulrich collection. This latter collection probably contains the largest series of Paleozoic bryozoa extant and is the result of thirty years of work on the part of Mr. Ulrich, with the assistance, at different times, of Mr. Charles Schuchert and the junior author. The Museum Paleozoic series has been augmented in the last few months by the collection of fossils made by Dr. Carl Rominger of the University of Michigan. In late years, large and excellent series of bryozoa have been collected for the Museum from horizons in which the Ulrich collection is lacking.

Dr. Frank Burns of the U. S. Geological Survey, during the course of his work in the Tertiary rocks, has collected many bryozoa in horizons where they were formerly supposed to be wanting. Dr. T. Wayland Vaughan has also discovered many bryozoa during the progress of his studies on the Tertiary corals of America. The study of these Tertiary collections is under way and it is hoped in the near future to publish papers on the subject.

All of the five orders of bryozoa comprising the subclass *Gymnolemata* are represented in the Paleozoic rocks. Both species and specimens of the order *Ctenostomata* are usually rare. The *Trepotomata*, *Cryptostomata*, and *Cyclostomata* are quite abundant and commonly form a considerable part of the fauna. The *Chilostomata*, which includes so many Cenozoic and recent species, is doubtfully recognized in the Paleozoic, the single genus *Paleschara* probably belonging to this order.

We deem it only right to introduce here an explanation concerning the bryozoan chapter in the American edition of Zittel's *Text-book of Paleontology*. Several authors have alluded to the fact that the same genera occur both among the bryozoa and the corals. The explanation is very simple.

The coral chapter had been translated without revision and

<sup>1</sup> *Proc. U. S. National Museum*, xxvi, 1903, pp. 565-591.

printed before Mr. Ulrich had been asked to revise the chapter on the Bryozoa. When the manuscript for the latter was submitted, the author and the editor objected to the duplicate treatment of the Monticuliporoids, but withdrew their objection when Mr. Ulrich presented satisfactory evidence of the correctness of his classification.

In this connection it may be well to state also that, in the opinion of the writers, no valid objection to the reference of the Monticuliporoids and Fistuliporoids to the Bryozoa has ever been made. None of the recent critics on Lindstrom's, Rominger's, and Ulrich's reference of these fossil organisms with the Bryozoa is deemed of sufficient importance to demand serious attention. As to Waagen and Wentzel,<sup>1</sup> they appear to have known little of the American literature on the subject. Had they been better informed also concerning the wonderful abundance and variety of the Monticuliporoids and related organisms in American Paleozoic deposits, it is scarcely probable that they would have based a new classification on a very small collection of poor specimens.

Many facts bearing upon the relations of the Monticuliporoids to the later Bryozoa have come to light since the publication of the *American Paleozoic Bryozoa* by Ulrich in 1882. At some future time we shall marshal these facts in the hope that their publication may finally fix the position of these disputed forms.

In the present series of papers the efforts of the authors are directed primarily to the consideration of the generic groups, and in only one order, the *Ctenostomata*, a relatively small group considered in this paper, are all the known species considered.

#### Order CTENOSTOMATA Busk.

The earliest notice of the Paleozoic fossils, which seem now to be very generally accepted as imperfect remains of ancient representatives of Ctenostomatous Bryozoa, was by Nicholson and Etheridge, Jr., in 1877. In that year these acute observers published a paper in the *Annals and Magazine of Natural History* entitled "On Ascodictyon, a new Provisional and Anomalous Genus of Paleozoic Fossils." Three species of the new genus were described and well illustrated in this paper, namely, *Ascodictyon stellatum* and *A. fusiforme* from the Hamilton shales at Widder, Ontario, and *A. radians* from the Lower Carboniferous limestone of Scotland.

In discussing the systematic position and affinities of these species, the authors say that specimens were submitted to several authorities

<sup>1</sup> *Palaeontologica Indica*, series XIII, 1886.

on the lower classes of invertebrates, among them Professor Huxley, who "suggested they might be Protozoans," H. B. Brady, who concluded that they cannot belong to the Foraminifera, and Mr. Hincks, who, with clear insight, "suggested that they were possibly allied to the recent *Actea*." Nicholson and Etheridge were at first inclined to consider them as peculiar Foraminifera, but seem to have abandoned this view when Brady failed to see any such affinities in them. Other possible affinities suggested by them are with *Hydrozoa*, of which some of the stoloniferous Sertularians present certain points of resemblance. Their conclusion, after briefly weighing the possibilities is to "leave the question as to the systematic position of *Ascodictyon* . . . undecided."

In the same year Dollfus described *Terebripora capillaris*,<sup>1</sup> a new bryozoan from the Devonian of France and evidently a representative of the Ctenostomata.

In 1879<sup>2</sup> Ulrich proposed a new genus, *Rhopalonaria*, for another type of these obscure organisms. The genus was placed in the bryozoan family *Crisiida*, and the only species then known, well described and illustrated. Being at that time quite unacquainted with the Ctenostomatous Bryozoa, the true position of the fossil was not recognized.

In 1881<sup>3</sup> G. R. Vine published descriptions of two Silurian species of *Ascodictyon*, one of which was named *Ascodictyon stellatum* var. *siluriense*, and the other doubtfully referred to *A. radians* Nicholson and Etheridge, Jr.

In a subsequent paper, published February, 1882,<sup>4</sup> Vine gives fuller details and figures of the Silurian species, and proposes two new names, *Ascodictyon radiciformis* for most of the forms previously referred by him to *A. radians*, and *Ascodictyon filiforme*, new species.

In 1884 this author published a third paper on *Ascodictyon*<sup>5</sup> in which, as he says in a subsequent publication, he "did his best to grapple with the systematic position of these fossils." Following a review of the literature, he "ventured on a new departure on my [his] own account." This is embodied in his remarks on p. 87

<sup>1</sup> *Bull. Soc. Lin. Normandie* (3), 1, 1877.

<sup>2</sup> *Jour. Cin. Soc. Nat. Hist.*, 11, p. 26.

<sup>3</sup> "Silurian Uniserial Stomatopora and Ascodictya," *Quart. Jour. Geol. Soc. London*, xxxvii, pp. 613-619.

<sup>4</sup> "Notes on the Polyzoa of the Wenlock Shales, etc.," *Quart. Jour. Geol. Soc. London*, xxxviii, pp. 44-68.

<sup>5</sup> "Notes on Species of *Ascodictyon* and *Rhopalonaria* from the Wenlock Shales," *Ann. & Mag. Nat. Hist.*, ser. 5, xiv, pp. 77-89.

(op. cit.): "There are not, so far as I am aware, any Cyclostomatous Polyzoa which may be considered as truly stoloniferous. Some of the Hydrozoa are, but I know of none whose stolons are adherent to stone or shell, such as are found in these ancient rocks; neither am I aware that the stoloniferous Ctenostomatous Polyzoa are adherent to stone or shell, like *Ascodictyon* or *Rhopalonaria*. Yet it seems to me that we have in *Ascodictyon filiforme*, at least, primitive representatives of stoloniferous *Vesiculariida*, such as *Vesicularia* or *Bowerbankia*, or possibly some member of the more humble race of the *Entoprocta*. Barrois has spoken of a pro-Bryozoan race, composed of free swimming organisms. May *Ascodictyon* be the attached or larval form of some of the as yet unknown pre-Upper Silurian types of organic life, polyzoan or otherwise?" The name *Rhopalonaria botellus* is suggested for a new type of these fossils.

In 1887, in a paper entitled "Notes on the Polyzoa of the Wenlock Shales, etc.,"<sup>1</sup> Vine gives further figures and descriptions of previously known Wenlock species of *Ascodictyon* and *Rhopalonaria*. In this paper the "Ascodictyæ" are referred to the *Stomatoporida*, which are Cyclostomata.

*Terebripora capillaris* Dollfus and *T. vetusta* new species are described by Oehlert in 1888 in an article entitled "Description de Quelques Espèces Dévoniennes du Département de la Mayenne."<sup>2</sup> Both species are apparently Ctenostomata of the genus *Rhopalonaria*, although we refer the latter doubtfully to this genus. Another foreign species which we doubtfully refer to *Rhopalonaria* is *Entobia antiqua* described by Portlock in 1843.<sup>3</sup>

In March, 1890,<sup>4</sup> Ulrich proposed a new genus, *Vinella*, "for an adnate form supposed to be a Ctenostomatous bryozoan, with relations to *Vesicularia* Thompson, and probably also to *Mimosella* Hincks." The fossil remains described and illustrated in this paper were interpreted as representing "the stoloniferous part of the bryozoan only," the zoëcia themselves being regarded as "having been deciduous and developed by budding from the creeping stolons at the parts now represented by small pores." Vine is credited as being the first to suggest the relation of *Rhopalonaria* and *Ascodictyon* to the Ctenostomatous Bryozoa.

In the same year appeared volume VIII of the reports of the Geological Survey of Illinois. The volume contains a revised

<sup>1</sup> *Proc. Yorkshire Geol. & Polytech. Soc.*, IX, p. 179.

<sup>2</sup> *Bull. Soc. d'Etud. Sci. d'Angers*, XVII, 1888, pp. 65-111.

<sup>3</sup> *Rep. Geol. County Londonderry*, 1843, p. 360.

<sup>4</sup> *Jour. Cin. Soc. Nat. Hist.*, XII, p. 173.

classification of the American Paleozoic Bryozoa by Ulrich, and the first definite assignment of *Ascodictyon* and *Rhopalonaria* to the *Ctenostomata*. The two genera are referred to a single family—the *Ascodictyonidæ*.

In 1891<sup>1</sup> Whiteaves described a species clearly referable to our new genus *Allonema* as *Stomatopora moniliformis* Whiteaves. It is from the Devonian, forty miles above the mouth of Hay river, Canada.

In 1892,<sup>2</sup> in a paper entitled "British Paleozoic Ctenostomatous Polyzoa," Vine again takes up the discussion of the *Ascodictyonidæ*, and returns to the opinions representing their relations suggested in his paper of 1884. Beginning with a good review of the subject, the paper continues with brief but pertinent remarks on five of the living families of the *Ctenostomata*, and concludes with descriptions of and critical remarks on the ten British species now referred more or less confidently to the *Ctenostomata*. Of these, *Ascodictyon youngi* Vine, from the Lower Carboniferous shales of Scotland, is described for the first time.

In January, 1893, when advance copies of the work were distributed, and in 1895, when the volume of which it is a part was issued,<sup>3</sup> Ulrich republished the original diagnosis and figures of *Vinella*. Accompanying this are figures and descriptions of two other forms of this genus, *Vinella radialis* Ulrich, and *Vinella radiformis* var. *conferta* Ulrich, and also of *Ascodictyon stellatum* Nicholson and Etheridge, Jr., and *Rhopalonaria venosa* Ulrich. The propriety of including the three genera *Ascodictyon*, *Vinella*, and *Rhopalonaria* in one family, the *Ascodictyonidæ*, is doubted. The author states further that he is "satisfied that *Rhopalonaria* at least, which is evidently related to the recent *Arachnidium* Hincks, belongs to a distinct family." This family, *Rhopalonariidæ*, was recognized by Nickles and Bassler in the classification published by them in 1900.<sup>4</sup>

In 1897<sup>5</sup> Simpson published copies of descriptions and figures of some of the Paleozoic Ctenostomata described by previous writers. No new matter is added concerning the order of Bryozoa under consideration. Miller's brief description of *Ascodictyon* and

<sup>1</sup> *Contr. to Canadian Paleontology*, vol. I, p. 212.

<sup>2</sup> *Proc. Yorkshire Geol. & Polytech. Soc.*, n. s., XII, pt. I, pp. 74-93.

<sup>3</sup> *Geol. of Minnesota*, Final Rept., III, pt. I, chap. iv, "On Lower Silurian Bryozoa of Minnesota."

<sup>4</sup> "Synopsis of the American Fossil Bryozoa," *Bull. 173, U. S. Geol. Surv.*, p. 19.

<sup>5</sup> *Fourteenth Ann. Rep. State Geol. New York*.

register of American species in his *American Geology and Paleontology*, 1898, and similar treatment of *Vinella* in the Supplement published three years later, likewise add nothing new to the subject.

The above references, it is believed, constitute a complete historical sketch of the subject. As we describe, or at least make critical remarks about every known species, and, with few exceptions, give one or more figures of each, this work might perhaps justly claim the rank of a monograph. However, we are far from claiming any such dignity for our effort, its aim being no higher than the production of something that might prove a useful basis for further investigations.

It should be stated in this connection that we know little about these fossils, and while their classification with the Ctenostomata is perhaps a little better than a mere working theory, it rests mostly on highly suggestive resemblances between the incomplete fossil organisms and the supposed corresponding parts of living forms, and upon conjectures as to the unknown parts. Still, whatever position may ultimately be assigned to them, it seems certain that their reference to the Ctenostomatous Bryozoa is at present opposed by fewer objections and at the same time supported by more and stronger agreements than appear when they are compared with any other class of organisms.

The only objection that might be considered valid is the difference between the chemical constituents of the zoarium of the recent Ctenostomata and their supposed Paleozoic ancestors. In the former the zoarium is either horny or membranaceous, and in many cases perhaps quite incapable of preservation in the fossil state. In the ancient types, on the contrary, the zoarium, though not by any means so calcareous as in other types of Bryozoa, nevertheless contained enough hard and resistant matter to render them capable of fossilization. In some the preservation is generally good, in others rarely satisfactory, while all exhibit unmistakable differences in the composition of their zoaria when compared with associated similarly adnate but purely calcareous zoaria of Cyclostomata like *Stomatopora*. Unfortunately we are unable to say what these differences consist of, but we have no reason to doubt that they are of kinds comparable with those existing between recent Cyclostomata and Ctenostomata.

Of the various forms referred to here as Paleozoic Ctenostomata, none, with the possible exception of *Rhopalonaria*, is known by its zoecia. Assuming provisionally that the fusiform swellings of *Rhopalonaria* are really the zoecia, we are at once confronted by



the difficulty of explaining why they seem to be without clearly defined orifices. A small spot may often be detected that looks different from the rest of the swelling, and that most probably represents some kind of orifice, but none of the numerous specimens before us is in a state of preservation good enough to establish its nature beyond doubt.

Considering the non-calcareous character of the zoecia of recent Ctenostomata in connection with the fact that the preservation of the zoarium of *Rhopalonia* shows that it also was not composed of material favorable to ordinary fossilization, the lack of definiteness about the zoecial orifice of the fossils may justly be regarded as confirming an alliance with Ctenostomata rather than as purely negative evidence. As a rule, nothing remains of the *Rhopalonia* but the peculiar and characteristically arranged, excavated counterfeits of the parasitic zoecia and stolons in the test of the host. Occasionally we meet with the fossilized zoarium itself. This is nearly always dark in color and more or less pyritized. Very rarely it is preserved as a siliceous pseudomorph, the silicification of the zoarium having taken place prior to the solution and removal of the calcareous shell in which it was partly imbedded.

Comparing what we know of *Rhopalonia* with recent Ctenostomata, we find a striking agreement in the form, connections, and arrangement of the zoecia of *Arachnidium*, of which we present in plates LXV and LXVI somewhat sketchy copies of figures of two species by Hincks. The zoecial orifice in *Arachnidium*, it will be observed, is small, and (a fact not brought out in our figures), is covered by a pyramid of stout setæ forming a closure quite different from those occurring in either the Chilostomata or Cyclostomata. With these minute plates in place, it may be quite readily conceived that even under favorable conditions of fossilization, the position and character of the zoecial orifice of a fossil *Arachnidium* would be obscure. The zoecial orifice in the recent species, it will be further observed, is near the distal extremity of the zoecium. In *Rhopalonia* this is not the case, since the possible zoecial orifice in the fusiform swelling is generally much nearer the center.

Viewing *Rhopalonia* as the creeping base of some otherwise unknown bryozoan, the subcentral position of the orifice-like spot becomes significant, for we can now see that it corresponds in all essential respects with the creeping base of a recent *Ætca*. Plate LXV, 1, 2, illustrates portions of the base of two species of that genus, *A. anguinea* and *A. truncata*, the former showing also some of the erect zoecia. At the attached basal end of the zoecia there is a

minute perforation in the corresponding subfusiform swelling of the adnate base. The position of this perforation is generally more nearly central than terminal, and thus corresponds with the facts observed on *Rhopalonaria*. The only feature in which the known parts fail to correspond is the greater regularity of the development and arrangement of the fusiform swelling of the base in the *Rhopalonaria*. This surely cannot be of sufficient consequence to deter us from classifying *Rhopalonaria* as an ancient representation of the *Æteidæ* and more typical Ctenostomata.<sup>1</sup>

The method of growth prevailing in *Rhopalonaria* is exactly duplicated in D'Orbigny's genus *Terebripora*,<sup>2</sup> the known species of which are described and in part figured by Fischer.<sup>3</sup> There is, however, a notable difference between the latter genus which contains recent species chiefly and the Paleozoic *Rhopalonaria*, namely, that in *Terebripora* the cell between the connecting stolons is the zoecium itself with a subterminal orifice bearing a sinus on its lower margin. *Terebripora* agrees in all essential respects with such Chilostomata as *Hippothoa*, and there can be little doubt that it also is a member of this order. It would be very desirable in the present state of our knowledge that some one should undertake the study of these recent forms in the hope of throwing some light on their possible Paleozoic representatives.

The delicate thread-like creeping stolons of *Vinella* and *Heteronema*, new genus, with their median rows of small pores, are, we believe, strictly comparable with the branching stems which support the deciduous zoecia of *Vesicularia*, a typical Ctenostomatous bryozoan. In plate LXV, 4, 5, are reproduced two of Hincks' illustrations, somewhat reduced, of *V. spinosa* Linnæus. Comparing these with *Vinella*, we observe no differences of greater importance than such as might be expected between members of the same order of organisms. Indeed, they are often greater, as in the case of *Arachnidium* and *Vesicularia*, a comparison of whose zoaria constantly brings out more distinctions than can be made out between those of *Vesicularia* and *Vinella*. The point that is deemed the most significant in the comparison is the row of pores on the branching stem in the one case and the creeping stolons in the other, which in the case of *Vesicularia* do, and in *Vinella* are believed to, mark the

<sup>1</sup> Hincks (*British Marine Polyzoa*) arranges *Ætea* with the *Chilostomata*, but admits the Ctenostomatous affinities of the genus. In our opinion the latter predominate decidedly over the former.

<sup>2</sup> *Voyage dans l'Amérique Merid.*, t. VI, 1839, p. 23, pl. x.

<sup>3</sup> *Nouv. Arch. Mus. Hist. Nat.*, II, 1866, pp. 293-313, pl. XI.

attachment of the zoëcia. The fact that the recent forms are erect and the fossil ones parasitic is not of much consequence, since the same difference occurs over and over again between many otherwise closely related genera of Bryozoa.

Vine (op. cit., 1892) has already pointed out most of the similarities of structure existing between *Ascodictyon* and our proposed *Allonema*, on the one hand, and the recent genus *Valkeria* on the other. Our reproduction of one of Hincks' figures of *Valkeria ura* shows the two features principally relied on in comparing *Valkeria* with *Allonema*, namely, the jointed character of the stem and the pores on the segments marking the points where the deciduous zoëcia were attached. The form of the zoëcial buds and their frequent arrangement in verticils, as in the upper branch on the left side of the figure, are, as pointed out by Vine, extremely suggestive of *Ascodictyon*. It is to be contended, however, that if the vesicles of *Ascodictyon* are zoëcia, then they must, in all cases observed by us, be only either young or abortive ones. We are inclined to doubt this and to regard them rather as a special kind of zooid, in which case the true zoëcia still remain to be discovered. The great variation in size of the vesicles shown by our figures of the known species on plate LXVIII, is regarded as supporting the latter view, such a variation in the zoëcia appearing quite unlikely to us.

The various alliances indicated in the foregoing comparisons make it clear that, even in a confessedly provisional classification, a single family should no longer be made to include all the various types now classed as Paleozoic Ctenostomata. Even with the recognition of a second family, the *Rhopalonariidæ*, the necessities of the case are not satisfied. Indeed, the need of a third family is only emphasized by the adoption of the second. It might be suggested that if *Vinella* and the related genus *Heteronema* are to be eliminated from the *Ascodictyonidæ*, that they be referred to the recent family *Vesiculariidæ* with which we have compared them. That step, however, seems to us much more objectionable than the erection of a new family for their special benefit, since it would indicate a degree of relationship that is scarcely warranted by our present knowledge, and certainly a greater one than we are willing to admit at present.

Under the circumstances the following provisional arrangement of the genera and species seems to us the least objectionable. Time and further research alone can determine whether or not it is based on facts insuring its permanence:

## Order CTENOSTOMATA Busk.

## Family RHOPALONARIIDÆ Nickles and Bassler.

## Genus RHOPALONARIA Ulrich.

- R. venosa* Ulrich. Ordovician—Richmond formation.  
*R. attenuata* new species. Silurian—Clinton limestone and Rochester shales.  
*R. ? antiqua* (Portlock). Silurian of Ireland.  
*R. robusta* new species. Devonian—Camden chert.  
*R. tenuis* new species. Devonian—Hamilton formation.  
*R. medialis* new species. Devonian—Hamilton formation.  
*R. capillaris* (Dollfus). Devonian of France.  
*R. ? vetusta* (Oehlert). Devonian of France.  
*R. keokukensis* new species. Mississippian—Keokuk formation.

## Family VINELLIDÆ new family.

## Genus VINELLA Ulrich.

- V. repens* Ulrich. Ordovician—Black River formation.  
*V. radialis* Ulrich. Ordovician—Lorraine formation.  
*V. radiformis* (Vine). Silurian—Wenlock and Rochester shales.  
*V. radiformis conferta* Ulrich. Silurian—Waldron shales.  
*V. ? multiradiata* new species. Silurian—Rochester shales.  
*V. ? radians* (Nich. & Ethr., Jr.). Carboniferous of Scotland.

## Genus HETERONEMA new genus.

- H. capillare* new species. Silurian of Gotland.  
*H. ? contextum* new species. Ordovician—Lorraine formation.  
*H. carbonarium* new species. Pennsylvanian.

## Genus ALLONEMA new genus.

- A. botelloides* new species. Silurian of Gotland.  
*A. botellus* (Vine). Silurian of Gotland and England.  
*A. waldronense* new species. Silurian—Waldron shale.  
*A. subfusiforme* new species. Silurian of Gotland.  
*A. fusiforme* (Nich. & Ethr., Jr.). Devonian—Hamilton formation.  
*A. moniliforme* (Whiteaves). Upper Devonian.  
*A. moniliforme-aggregatum* new variety. Devonian—Hamilton formation.  
*A. ? minimum* new species. Pennsylvanian.

## Family ASCODICTYONIDÆ Ulrich (Restricted).

## Genus ASCODICTYON Nicholson and Etheridge, Jr.

- A. siluriense* Vine. Silurian—Rochester and Wenlock shales.  
*A. filiforme* Vine. Silurian—Wenlock shales.

- A. stellatum* Nich. & Ethr., Jr. Devonian—Hamilton formation.  
*A. floreale* new species. Devonian—Hamilton formation.  
*A. parvulum* new species. Mississippian—Chester group.  
*A. sparsum* new species. Mississippian—Chester group.  
*A. youngi* Vine. Carboniferous of Scotland.

*Position Doubtful.*

Genus PTYCHOCLADIA new genus.

- P. agellus* new species. Pennsylvanian.

Family RHOPALONARIIDÆ Nickles and Bassler.

Genus RHOPALONARIA Ulrich.

1879. *Rhopalonia* ULRICH, Jour. Cin. Soc. Nat. Hist., II, p. 26.  
 1882. *Rhopalonia* ULRICH, Ibid., v, p. 149.  
 1884. *Rhopalonia* VINE (partim), Ann. Mag. Nat. Hist., ser. 5, XIV, p. 84, fig. iv.  
 1887. *Rhopalonia* VINE (partim), Proc. Yorkshire Geol. and Polyt. Soc., IX, p. 185.  
 1889. *Rhopalonia* MILLER, North Amer. Geol. and Pal., p. 321.  
 1890. *Rhopalonia* ULRICH, Geol. Surv. Illinois, VIII, p. 367.  
 1892. *Rhopalonia* VINE, Proc. Yorkshire Geol. and Polyt. Soc., XII, p. 91.  
 1897. *Rhopalonia* SIMPSON, Fourteenth Ann. Rep. State Geol. New York for 1894, p. 603.  
 1900. *Rhopalonia* NICKLES and BASSLER, Bull. U. S. Geol. Surv., No. 173, p. 19.

Zoarium adnate, excavating the surface of the host so as to become usually about half embedded in it; consisting, so far as known, of fusiform internodes or cells connected by extremely delicate tubular stolons, the whole arranged in a primate manner. Zoecia unknown, probably deciduous and developed by budding from a subcentrally situated pore in the internodes.

Genotype *R. venosa* Ulrich.

The principal generic and family character is the faculty of excavating the body grown upon by the creeping base, the zoarium. As a rule nothing remains except these clay filled or empty excavations, but as they are sharp and true impressions of the stolons, and the species are distinguished chiefly by variations in their dimensions, the impressions serve quite as well in discriminating the species as the more complete specimens.

In the latter the stolons are in semi-relief and black in color, with the pores and possibly other surface features generally more or less obscured, or quite obliterated, by pyritization.

The known species are all Paleozoic, the oldest occurring in the

Richmond or closing age of the Ordovician, the last in the Keokuk formation of the Mississippian series.

In 1884, and again in 1887 (op. cit.), Vine described a *Rhopalonaria botellus* and thereby confused this and the other very different species upon which we found the new generic group *Allouema*. In 1886<sup>1</sup> Ulrich added to the confusion by describing a variety of *Stomatopora delicatula* James as *Rhopalonaria pertenuis*, an error that was corrected in his later work on Minnesota Bryozoa.

### RHOPALONARIA VENOSA Ulrich

(PLATE LXVI, 2, 3)

1879. *Rhopalonaria venosa* ULRICH, Jour. Cin. Soc. Nat. Hist., II, p. 26, pl. vii, 24, 24a.  
 1889. *Rhopalonaria venosa* MILLER, North Amer. Geol. and Pal., p. 321, fig. 511.  
 1893. *Rhopalonaria venosa* ULRICH, Geol. Minnesota, III, p. 114, fig. 8c.  
 1897. *Rhopalonaria venosa* SIMPSON, Fourteenth Ann. Rep. State Geol. New York for 1894, p. 603, fig. 221.

Zoarium growing on various bodies—corals, brachiopods, and shells of pelecypods. Cells distinctly swollen, fusiform, connected by very slender stolons of an average length equaling that of the cells, all arranged somewhat irregularly in a pinnate manner, an average of 5 or 6 cells in the midrib in 3 mm. and the same number in the lateral branches in 4 mm. Occasionally an arrangement simulating the web of a spider may be observed in large colonies. Fusiform cells averaging 0.1 mm. or less in diameter and about 0.3 mm. in length; many with a minute, elevated, eccentrically situated pore-like spot.

On account of the extreme simplicity of these fossils, we find it difficult to draw up satisfactory descriptions. The size, form, and arrangement of the cells and the relative average length of the connecting tubes are the points relied on in distinguishing the species. In recognizing these the illustrations will doubtless prove of greater service than descriptions, and the latter, therefore, will consist principally of comparative remarks.

*Occurrence.*—Richmond group, numerous localities in Ohio and Indiana. The types are from Waynesville and Clarksville, Ohio.

Cat. Nos. 43,111-43,115, U. S. N. M.

### RHOPALONARIA ATTENUATA new species

(PLATE LXVI, 4, 5)

In this species the length and arrangement of the internodes and stolons is practically the same as in *R. venosa*, but its colonies are

<sup>1</sup> *Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn.*, p. 59.

readily distinguished by the extreme tenuity of its parts, and the comparative rigidity of their arrangement. The fusiform swellings are not only narrower but also shorter and correspondingly farther apart. *R. tenuis* new species of the Hamilton formation is a similarly attenuate species but has longer cells.

Only the excavations or molds of this species have been seen.

*Occurrence*.—Rochester shale, Lockport, N. Y.; Clinton limestone, near Mifflintown, Juniata county, Pa.

Cat. Nos. 43,116, 43,117, U. S. N. M.

#### RHOPALONARIA ? ANTIQUA (Portlock)

(Not figured)

1843. *Entobia antiqua* PORTLOCK, Rep. on Geol. County Londonderry, p. 360, pl. XXI, fig. 5a.

1854. *Cliona antiqua* MORRIS, Cat. Brit. Foss., p. 27.

1866. *Terebripora ? Portlocki* FISHER, Nouv. Arch. de Mus. d'Hist. Nat. Paris, t. 12, p. 307.

A reinvestigation of the type or typical specimens is necessary before the generic position of this species can be determined without question, and until this is done we prefer to refer to the species as above. Although agreeing in most respects with *Rhopalonia*, Portlock's figure of *Entobia antiqua* presents a few characters that cause us to make the reference doubtfully.

*Occurrence*.—Silurian of Ireland.

#### RHOPALONARIA ROBUSTA new species

(PLATE LXVI, 6)

Of this species we have seen only a single colony, but its fusiform cells are so much larger and the connecting stolons so much shorter than any of the other forms known that we cannot hesitate in pronouncing it distinct. The fusiform cells average about 0.12 mm. in diameter and nearly 1.0 mm. in length. As usual the average length of those in the midrib is appreciably greater than of those forming the lateral branches and their connections.

The specimen occurs in a block of chert which contains numerous natural molds of brachiopods. Originally it grew upon the inner side of one of their valves. This was subsequently entirely removed by solution, nothing remaining now in the mold but a siliceous pseudomorph of the *Rhopalonia*. *R. capillaris* (Dollfus) from the Devonian of France is a closely allied species, but differs in having elongate elliptical cells connected by proportionally much longer and sharply defined stolons.

*Occurrence*.—Camden chert, Camden, Tennessee.  
Cat. No. 35,089, U. S. N. M.

**RHOPALONARIA TENUIS** new species

(PLATE LXVI, 7, 8, 9)

Fusiform cells attenuate, averaging about 3 in 2.0 mm., occasionally only 4 in 3.0 mm.; greatest diameter of same about 0.5 mm. On the best specimen many of the cells preserve remains of the pores. Of these there is usually only one situated near the center of the cell, but in others there appear to be two pores. The connecting stolons rarely equal the fusiform swellings in length, the average, however, is considerably less.

The general aspect of the colony is greatly like that of *R. venosa*, but when critically compared the fusiform cells of the Devonian species prove to be both narrower and longer, and the connecting stolons generally shorter than the Ordovician type of the genus. In the Silurian species, *R. attenuata*, the fusiform swellings, though about equally narrow, are considerably shorter and enlarge more abruptly, while the connecting stolons are much longer.

The original of figure 9, plate LXVI, is doubtfully referred to this species. It consists of the excavations only, but these are so closely arranged that it is difficult to make out the series. Evidently several branches cross each other.

*Occurrence*.—The figured type is from the lower shales of the Hamilton formation at Thedford, Ontario. The species also occurs in the same formation at Alpena, Michigan, and Eighteen-Mile creek, New York.

Cat. Nos. 43,118, 43,119, and 43,121, U. S. N. M.

**RHOPALONARIA MEDIALIS** new species

(PLATE LXVI, 10)

Compared with other species the colonies of this form appear less compact and the arrangement of the cells more straggling. In the matter of size, the fusiform cells are more robust than in any of the other forms except *R. robusta*, the position of the species in this respect being almost exactly intermediate between *R. robusta* and *R. venosa*. About 4 of the cells in the middle series occur in 3.5 mm., while of those in the lateral branches the average number in an equal space is about 5. The connecting stolons are rather short, the average length not exceeding two-thirds that of the fusiform swellings.

Compared more particularly with the associated *R. tenuis*, it is distinguished at once by its more robust aspect and looser habit of growth.



*Occurrence*.—Lower shales of Hamilton formation at Thedford, Ontario.

Cat. No. 43,120, U. S. N. M.

**RHOPALONARIA CAPILLARIS (Dollfus)**

(TEXT FIGURE 32)

*Terebripora capillaris* DOLLFUS, Bull. Soc. Linn. Normand. (3), 1, 1877, p. 96, pl. 1, figs. 2-4.

*Terebripora capillaris* OEHLERT, Bull. Soc. d'Etud. Sci. d'Angers, XVII, 1888, p. 107.

Judging from Dollfus' figure, a reduced copy of which is here reproduced as text figure 32, this species appears to be closely allied to our *Rhopalonaria robusta*, although in some respects it approaches the genotype *R. venosa*. Although agreeing with the former in size, *R. capillaris* is distinguished by the elongate elliptical rather than fusiform shape of its cells and by its proportionately much longer and more sharply defined connecting stolons. The greater regularity and more robust growth of *R. capillaris* will distinguish it from *R. venosa*.



FIG. 32.—*Rhopalonaria capillaris* (Dollfus).  $\times 9$ . Devonian of France.

*Occurrence*.—Devonian of France.

**RHOPALONARIA? VETUSTA (Oehlert)**

(TEXT FIGURE 33)

*Terebripora vetusta* OEHLERT, Bull. Soc. d'Etud. Sci. d'Angers, XVII, 1888, p. 108, pl. X, fig. 3.

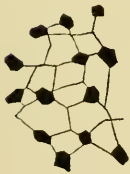


FIG. 33.—*Rhopalonaria? vetusta* (Oehlert).  $\times 9$ . Devonian of France.

Oehlert's illustration, of which text figure 33 is a reduced tracing, shows that this species does not conform strictly with *Rhopalonaria*, but that it is doubtless more closely related to this genus than to *Terebripora*. The differences from the typical forms of *Rhopalonaria* are particularly the arrangement of the cells and stolons and the short subangular form of the impressions of the cells. It is possible that the portion of the zoarium figured by Oehlert may represent a part where buds from neighboring branches, by growth over each other, obscured the regular development. The

other species of *Rhopalonaria* are so different that comparison is unnecessary.

*Occurrence*.—Devonian of France.

#### RHOPALONARIA KEOKUKENSIS new species

(PLATE LXVI, 11)

In this species the branches divide and throw off equal branches at such frequent intervals that the pinnate arrangement of the cells is generally very much obscured. The fusiform cells are narrow and vary from 0.5 mm. to 0.6 mm. from center to center. They are longer than the connecting threads, the relations of the former to the latter being, respectively, about as 3 is to 2.

The proportions of the cells and stolons are very similar to those found in the Devonian *R. tenuis*, still there is a slight difference in the length of their internodes, while the pinnate arrangement of the latter is much less obvious in *R. keokukensis* than in *R. tenuis*. If both forms had occurred in the same geological formation, we might have considered them as varieties of one species, but since the differences noted are supported by great disparity in their ages, we cannot hesitate to distinguish them specifically. In cases like this we should also remember that the unknown parts of the organisms most probably were more sharply differentiated.

*Occurrence*.—Keokuk formation, Keokuk, Iowa.

Cat. No. 43,122, U. S. N. M.

#### Family VINELLIDÆ new family

In its simplest form, *Heteronema*, the creeping base of this family, consists of usually simple, though locally jointed, delicate, partially ramifying, orderless tubular threads. Where pores have been observed on these they always occurred in a single row. As a variation from this simplest type, we have *Vinella*, consisting of similar delicate threads but having them arranged in such manner that they proceed from more or less definite centers. In the third generic type, *Allonema*, the orderless arrangement of the threads observed in *Heteronema* is maintained, but its segmentation has assumed the importance of a constant character and instead of a single row of pores the internodes are covered with them. Perhaps, on account of the last feature, *Allonema* should have been arranged with *Ascodictyon* rather than *Vinella*, the punctate internodes being comparable with the similarly punctate vesicles of that genus. Possibly they are homologous, even, but in either case *Ascodictyon* possesses charac-

ters not found in the *Vinellidæ*, namely, two permanently and widely distinct structures—bulbous vesicles and extremely delicate connecting stolons. If the simple or segmented threads of the *Vinellidæ* are, as we believe, homologous with the vesicles of *Ascodictyon*, then the connecting stolons of the latter are wanting in this family. If, on the other hand, they represent the stolons, then there is nothing to compare with the vesicles.

#### Genus VINELLA Ulrich

1890. *Vinella* ULRICH, Jour. Cincinnati Soc. Nat. Hist., XII, p. 173.  
 1892. *Vinella* MILLER, North Amer. Geol. and Pal., First app., p. 685.  
 1892. *Vinella* VINE, Proc. Yorkshire Geol. & Polyt. Soc., XII, p. 84.  
 1893. *Vinella* ULRICH, Geol. Minnesota, III, p. 112.  
 1897. *Vinella* SIMPSON, Fourteenth Ann. Rep. State Geol. N. Y. for 1894, p. 604.  
 1900. *Vinella* NICKLES AND BASSLER, Bull. U. S. Geol. Surv., No. 173, p. 19.

Zoarium parasitic, consisting of very slender, tubular threads or stolons, arranged more or less distinctly in a radial manner. Surface of threads with a single row of small pores. These may be wanting locally, and vary considerably in the degree of their separation. Zoecia unknown, probably deciduous.

*Genotype*.—*V. repens* Ulrich.

Of the following species only the genotype and *V. radiformis* (Vine), together with its variety *conferta* Ulrich, are confidently referred to this genus. As to Nicholson and Etheridge's *Ascodictyon radians*, from the Carboniferous of Scotland, we are satisfied that it is not an *Ascodictyon* and equally confident that it is nearer to *Vinella* than it is to the typical forms of the genus in which it has hitherto been placed. Still, the considerable thickness of the inner parts of the radii and the root-like taper of their distal halves give the organism an aspect that certainly *looks* different from the more typical species of *Vinella*. Excepting, of known characters, that its radii maintain approximately the same diameter (*i. e.*, they do not taper), our new species *V.?* *multiradiata*, may be said to parallel the Carboniferous species. Both have a central cup, with a raised border that possibly represents the broken base of an erect zoecium like those in the recent *Cylindroecium dilatatum* Hincks (see plate LXV, 3). The only known example of *V.?* *multiradiata*, unfortunately, has suffered enough from weathering to obliterate whatever minute structure it may have possessed, so we are unable to decide as to its true affinities. The species *radians*, however, is said to occur abundantly and, apparently in a state of preservation sufficiently

favorable to justify the hope that an examination of good specimens may throw further light upon its systematic position. In the meantime we propose to arrange the species as a doubtful *Vinella*.

### VINELLA REPENS Ulrich

(PLATE LXVIII, 1-3)

1890. *Vinella repens* ULRICH, Jour. Cincinnati Soc. Nat. Hist., XII, p. 174, fig. 1.  
 1893. *Vinella repens* ULRICH, Geol. Minnesota, III, p. 114, pl. 1, figs. 1-5.  
 1897. *Vinella repens* SIMPSON, Fourteenth Ann. Rep. State Geol. New York for 1894, p. 604, fig. 222.  
 Not *Vinella repens* VINE, 1892, Proc. Yorkshire Geol. & Polyt. Soc., XII, p. 84, pl. iii, figs. 1-4. (= Probably *Heteronema*, sp. undet.)

*Original description*.—"Zoarium repent, the stolons delicate, thread-like, often longitudinally striate, straight or flexuous; from 0.06 to 0.11 mm. in diameter; bifurcating often and sometimes arranged in a radial manner about a central node. Where best preserved, very small pores arranged uniserially along the center of the upper surface of the threads; about 11 in 2.5 mm. Zoecia unknown, probably deciduous."

We have no amendments to make to the original description of this species reprinted above. A few additional specimens have been found, but these add nothing to the features observed in the type lot of specimens.

In Vine's last paper on Paleozoic Ctenostomata (loc. cit.), he identifies this species among his Wenlock fossils, and distinguishes another form as a variety *contorta*. Neither the descriptions nor the figures given by Vine are satisfactory, but using them in connection with private information we have arrived at the conclusion that they are quite distinct from this species and probably not even congeneric. Both are believed to belong to *Heteronema* and possibly to the species which we describe as new under the name *H. capillare*.

*Occurrence*.—Phylloporina beds of the Black River formation, St. Paul, Minnesota.

Cat. No. 43,148, U. S. N. M.

### VINELLA RADIALIS Ulrich

(PLATE LXVIII, 4)

1893. *Vinella radialis* ULRICH, Geol. Minnesota, III, p. 113, fig. 8b.

In this delicate species the radial disposition of the threads is well developed. In the original and only known specimen there are four complete centers and rays and parts of two others. The rays are rigid, 4 to 7 mm. long and vary in number in each set from seven to

seventeen. The preservation of the specimen is not favorable enough to show either the pores on the threads or character of the centers.

*Occurrence*.—Corryville beds of the Lorraine formation, Cincinnati, Ohio.

Cat. No. 43,149, U. S. N. M.

### VINELLA RADICIFORMIS (Vine)

(PLATE LXVIII, 7)

1881. *Ascodictyon radians* VINE (part), Quart. Jour. Geol. Soc. London (provisional placement), xxxvii, p. 619.

1882. *Ascodictyon radiforme* VINE, Ibid., xxxviii, p. 53, figs. 1, 3.

1884. *Ascodictyon radiforme* VINE, Ann. & Mag. Nat. Hist., ser. 5, xiv, p. 83, figs. 1-5.

1887. *Ascodictyon radiforme* VINE, Proc. Yorkshire Geol. & Polyt. Soc., ix, pp. 183-4, pl. 12, fig. 5.

1892. *Ascodictyon radiforme* VINE, Ibid., xii, p. 87.

1893. *Vinella radiformis* ULRICH, Pal. Minnesota, iii, pt. 1, p. 113.

This species is distinguished from *V. repens* by the much greater tenuity of the zoarial threads, their average thickness in the one being about 0.08 mm. and in the other between 0.03 and 0.04 mm. In the immediate vicinity of the centers the radii are slightly swollen, and this character affords another point of difference.

In the typical form of the species the nuclei of the rays are widely separated and often difficult to distinguish from the points where the rays merely cross each other. The rays often appear to, and probably do, bifurcate, and, on the whole, seem to meander about without much order. Sometimes they suggest *Heteronema capillare*, in which there are no nuclei, but, as they are considerably finer than in that species, there is little excuse for confusing them.

*Occurrence*.—Buildwas beds of the Wenlock shales, Shropshire, England; Rochester shales, Lockport, New York.

Cat. No. 43,146, U. S. N. M.

### VINELLA RADICIFORMIS CONFERTA Ulrich

(PLATE LXVIII, 5, 6)

1893. *Vinella radiformis* var. *conferta* ULRICH, Geol. Minnesota, iii, p. 113, fig. 8, c, d.

This variety or closely related species may be distinguished usually without much trouble by the much greater frequency of its nuclei, more numerous radii, and slightly thicker threads. In the larger nuclei the center is commonly depressed. As to the radial threads, they are sometimes jointed, and in such cases each of the rather short internodes carries a single pore.

*Occurrence*.—Waldron shale, Waldron, Indiana.  
Cat. No. 43,147, U. S. N. M.

**VINELLA? MULTIRADIATA** new species

(PLATE LXVIII, 8)

The specimen on which this peculiar species is founded incrusts a crinoid column, about three-fourths of an inch in length, about two-thirds covered with the supposed *Vinella*. At intervals varying from little more than 0.5 mm. to about 2.0 mm. the surface of the incrusting sheet presents subcircular, cup-shaped depressions, 0.12 mm. to 0.2 mm. in diameter, enclosed by a low rim from which 14 to 20 closely arranged threads proceed in all directions. The radii are commonly disposed in sets of three to five, those emanating from neighboring centers overlapping and interweaving in the interspaces. The sheet seems to consist in most parts of at least two superposed layers. Minute details of structure not preserved.

At first sight, under a low power of magnification, the specimen recalled the attached basal disks of articulating Bryozoa like *Arthropora* and *Escharopora*, but it soon became evident that the resemblance was deceptive and extended only to the common possession of cup-shaped depressions and lines radiating from them. Under a higher power the radii proved to be simple threads and not radially arranged walls separating rows of elongated zoecial apertures, which is the structure of the attached disks of the articulating Bryozoa referred to. Of course the much smaller size of the *Vinella* was apparent from the beginning of our investigations. Though now thoroughly satisfied that we are not dealing with bases of zoaria, we think it quite possible that they may prove to be the bases of isolated zoecia. Whatever the future may prove it to be, it impresses us as a very interesting organism, and it is the hope that other collectors may succeed in finding more and better specimens that has induced us to describe it.

*Occurrence*.—Rochester shale, Lockport, New York.  
Cat. No. 43,144, U. S. N. M.

**VINELLA? RADIANS** (Nicholson and Etheridge, Jr.)

(PLATE LXV, 9, 10)

1877. *Ascodictyon radians* NICHOLSON AND ETHERIDGE, JR., Ann. & Mag. Nat. Hist., ser. 4, XIX, p. 465, pl. 19, figs. 9-11.  
1887. *Ascodictyon radians* VINE, Proc. Yorkshire Geol. & Polyt. Soc., IX, p. 184.  
1892. *Ascodictyon radians* VINE, Ibid., XII, p. 90.  
Not *Ascodictyon radians* ? VINE, 1881 (= *Vinella radiformis* (VINE)).

Having no specimens of this species, we can do no better than to republish the following original description and remarks by Nicholson and Etheridge, Jr. (loc. cit.):

"*Spec. char.* Colony composed of elongated vesicles, broad at their bases, thickened out in the middle of their length, and gradually attenuated towards their extremities, disposed in stellate clusters or rosettes. The bases of the tongue-like or somewhat fusiform vesicles are placed round a central circular depression; and their length varies from a sixth to more than a fourth of a line. Each rosette consists of from ten (sometimes fewer) to fifteen or twenty vesicles; and the free surface of each carries a single median row of excessively minute, somewhat slit-like, closely approximated pores. The rosettes are connected together by delicate creeping filaments, which may spring from the bases of the rosettes or from the attenuated extremities of the vesicles, and which generally anastomose, so as to form a network or mycelium.

"*Obs.* In its general structure and arrangement this species is related to *A. stellatum*, though sharply distinguished by the very elongated form of the vesicles and the presence of but a single row of pores on each. All the rosettes, when well preserved, show a circular central cavity or depression, with a distinct bounding wall; but we have been unable to make out the true nature of this, or its relation to the vesicles. When the vesicles are very numerous, they are smaller in size than when the rosette consists of fewer; but in all cases each shows a dark median line, which, when highly magnified, resolves itself into a line of minute close-set pores. The stolons may ramify and form a network; or a single stolon, proceeding directly from the end of a vesicle in one rosette, may be prolonged at once into the attenuated termination of a vesicle belonging to another rosette. Weathered specimens show clearly that the vesicles are traversed by a long tubular cavity, corresponding in form with the shape of these structures themselves; and they sometimes show what appear to be apertures at their bases. The stolons also are, doubtless, tubular, and they probably carry a median row of pores on their free faces, though we have not been able to determine either of these points to our satisfaction."

Judging principally from the published figures, of which we present tracings reduced one-third, this remarkable species cannot remain in the genus *Ascodictyon* as restricted by us. As remarked under the preceding generic description, the species is nearer *Vinella* than *Ascodictyon*, and it is here that we propose to place the species until its reëxamination proves it to belong elsewhere. So far as its char-

acters are known, the outward taper of the rays indicates relations with *V. radiceiformis*, while in the number of its rays, in the central depression, and in its general expression it seems to agree better with our *V. ? multiradiata*.

*Occurrence*.—Lower Carboniferous of Scotland.

#### Genus HETERONEMA new genus

? 1892. *Vinella* (part) VINE, Proc. Yorkshire Geol. and Polyt. Soc., XII, pp. 84, 85.

Zoaria, so far as known, consisting of usually simple, or locally jointed, delicate, sparsely ramifying, tubular, creeping threads, arranged without apparent order. Pores rarely observed, apparently always in a single row.

*Genotype*.—*H. capillare* new species.

This, the most simple type of the family, has been confounded with *Vinella*, but we believe it necessary to distinguish it because of its extremely simple structure, and particularly on account of the absence of the highly characteristic nuclei, and consequent radial arrangement of the threads of *Vinella*. Regarding these nuclei as an essential feature of *Vinella*, we are enabled to present a more satisfactory and clearer definition of the genus than would be possible if species were included in which they are absent.

We have so far observed only three species of this type, and one of them is doubtful. The doubtful species is from Ordovician rocks, the genotype seems to be a common fossil in the Silurian of Gotland, and the third species a rare one in the basal part of the Coal Measures of Illinois. It is scarcely to be doubted that other forms will turn up when collections from intervening rocks are thoroughly searched.

#### HETERONEMA CAPILLARE new species

(PLATE LXV, 11)

Compare *Vinella repens* var. *contorta* VINE, Proc. Yorkshire Geol. and Polyt. Soc., XII, 1892, p. 85, pl. III, figs. 5-7.

Irregularly meandering threads, growing over shells and corals, sometimes scattering, at other times growing so abundantly that the crossing of the threads produces an irregular network. Threads tubular, slightly compressed, of uniform size, 0.035 mm. to 0.04 mm. thick, locally jointed. Pores not observed.

This form is readily distinguished from associated remains of Ctenostomatous Bryozoa by its delicate, irregularly intertwining, simple, creeping threads, which form colonies varying from a few scattering threads to patches an inch in diameter. It is possible that



Vine's *Vinella repens* var. *contorta* (loc. cit.) is founded on a specimen of this species, but we could not satisfy ourselves concerning this identity.

*Occurrence*.—Common in the Silurian of Gotland, probably also in the Wenlock shales of England.

Cat. No. 43,133, U. S. N. M.

**HETERONEMA? CONTEXTUM** new species

(PLATE LXV, 12)

The specimen upon which this species is founded forms a considerable patch over the celluliferous surface of a species of *Leptotrypa*, which had attached itself to the shell of an *Orthoceras*. The *Heteronema* ? is pyritized and in its present condition has a dark color. It forms a delicate though very irregular and often spiny network, the meshes of which are faithfully represented in plate LXV, 12. Whether the network was originally produced chiefly by the mere crossing of threads, or was wholly the result of this frequent bifurcation and anastomosis, cannot now be determined. The relation of the meshes to each other, however, inclines us to regard the latter explanation as more likely to prove true. Small, elevated points, occurring principally on the intersections, may represent pores.

The placing of this fossil under *Heteronema* can be defended only as a temporary arrangement. Indeed, we shall not be surprised if it proves to be not even a bryozoan. It may be a sponge.

*Occurrence*.—Corryville bed, Lorraine formation, Morrow, Ohio.  
Cat. No. 43,132, U. S. N. M.

**HETERONEMA CARBONARIUM** new species

(PLATE LXV, 13)

This species is distinguished from *H. capillare* on account of the greater strength and comparative rigidity of its threads. These are also more flattened, and hold a nearly uniform width, the extremes scarcely exceeding the difference between 0.06 mm. and 0.07 mm. A slight, transverse wrinkling of the surface may be observed, but as we could not satisfy ourselves that the feature is characteristic of the species, it was not shown in our illustration.

*Occurrence*.—Lower Coal Measures, Seville, Illinois.

Cat. No. 43,132, U. S. N. M.

Genus **ALLONEMA** new genus

1884. *Rhopalonaria* (part) VINE, Ann. Mag. Nat. Hist., ser. 5, XIV, p. 85, fig. iv, 3.

1887. *Rhopalonaria* (part) VINE, Proc. Yorkshire Geol. & Polyt. Soc., IX, p. 185, pl. 12, fig. 11 (? 12).

Fossil zoaria of which only the creeping base is known. This attaches itself to foreign bodies and consists of strings of sausage-like, bulbous fusiform or pear-shaped internodes or vesicles varying greatly in size in different species. Surface of internodes minutely punctate, while a number in each colony exhibit a larger pore-like depression, usually near one end of the vesicle or internode that is regarded as marking the point where erect zoëcia were attached.

*Genotype*.—*Allonema botelloides* new species.

The distinctive features of this genus, when compared with *Heteronema*, *Vinella*, and *Rhopalonaria*, are (1) the separation of the creeping base into distinct vesicles or connected internodes, and (2) the minutely punctate surface of same. The second character has been observed in all the species now referred to the genus except *A. ? minimum*. In distinguishing the various species we have been obliged to rely chiefly on differences in the size of the internodes. However, a certain average seems constant for each species, so that we have experienced little difficulty in classifying our collections.

*A. fusiforme* (Nicholson and Etheridge, Jr.) and our *A. subfusiforme* and *A. waldronense*, are closely related but depart in size of form and internodes obviously from the more typical Silurian and Devonian species of the genus. The latter compare in the form of their internodes with *Valkeria*, the former remind more of the basal vesicles of *Ætea*. As the zoëcial characters of these two recent genera are different enough to cause them to be widely separated in the classification of the Bryozoa, it is possible that these fossil bases likewise belong to zoaria with very distinct zoëcia. However, it will perhaps forever be impossible to determine this point, and our only reason for referring to the possibility is the wish to avert off-hand unfavorable criticism of our "species." These may in some cases appear to be drawn too fine, but we think not, and for two reasons: In the first place, all we have of these Bryozoa are the creeping bases to which the erect and solitary zoëcia were attached. In classifying recent Ctenostomata, very little dependence is placed on the bases, the family, generic, and even specific characters being derived almost entirely from those of the zoëcia. Our second reason is the unlikelihood of one and the same species passing from one geological system to the next, as, for instance, from the Silurian to Middle or Upper Devonian.

Concerning the systematic position of the new genus, it seemed at first that the punctate surface of the internodes, and their frequent isolation in some of the species, should be regarded as the determining

factors, and cause its reference to the *Ascodictyonida*. On further reflection, however, the absence of the delicate threads which connect the clustered or isolated vesicles in *Ascodictyon* appeared a more important factor and induced us to classify the genus with the *Vinellida*.

**ALLONEMA BOTELLOIDES** new species

(PLATE LXVII, 2-4)

In this species the internodes form strings of oblong, usually short, sausage-shaped links, averaging about 0.5 mm. in length and varying little from 0.25 mm. in width. In a colony holding this average, many of the links may be merely a little constricted or quite divided about the mid-length, while others may not be clearly divided from the next following links. Others again, especially where the links are crowded, will be abnormally narrow. Still, these variations do not seriously affect the general average of size and form of the internodes, nor the general aspect of the colony that is sufficiently characteristic to enable the observer to recognize the species at a glance. Traces of the surface puncture are nearly always preserved, but the larger zoöcial pore is not so often seen. In excellently preserved examples, less than half of the internodes exhibit evidence of having supported zoöcia.

Colonies of this species vary from a few internodes to others spreading over a space an inch or more across. They are readily distinguished from the associated *A. botellus* (Vine) by their more robust aspect, and proportionately shorter internodes.

*Occurrence*.—Common on corals in the Silurian of the Island of Gotland.

Cat. No. 43,126, U. S. N. M.

**ALLONEMA BOTELLUS** (Vine)

(PLATE LXVII, 1)

1884. *Rhopalonaria botellus* VINE, Ann. & Mag. Nat. Hist., ser. 5, vol. XIV, p. 85, fig. iv, 3; 1887, Proc. Yorkshire Geol. & Polyt. Soc., vol. IX, p. 185; pl. 12, figs. 11 (?12).

This species is associated with the genotype in the Silurian rocks of Gotland, and the two forms not infrequently occur on the same coral or shell. We have, however, experienced no serious difficulty in distinguishing them, Vine's species having always a decidedly more delicate aspect. The average lengths of the internodes is about the same in both, but on account of their lesser width in *A. botellus*, in which this dimension usually varies between 0.1 mm. and 1.15 mm., they are proportionately more elongate than in our *A. botelloides*.

Some internodes in most colonies of this species are distinctly club-shaped, and these usually exhibit a zoecial attachment pore.

*Occurrence*.—Silurian, Island of Gotland. Buildwas beds of Wenlock shales, England.

Cat. No. 43,125, U. S. N. M.

**ALLONEMA MONILIFORME (Whiteaves) and var. AGGREGATUM**  
new variety

(PLATE LXV, 14; PLATE LXVII, 9)

1891. *Stomatopora moniliformis* WHITEAVES, Cont. to Canadian Paleontology, vol. 1, p. 212, pl. 28, fig. 10.

*Original Description*.—"Polyzoary minute, creeping, attached by the whole of its under surface to some foreign object, very slender and fragile, consisting of a few irregularly disposed but more or less divergent rows of single cells, which, though uniserial, occasionally throw off lateral buds consisting of one or more cells, and which may, as in the specimen figured, proceed from a central or subcentral irregular aggregation of cells. Cells moderately convex, elliptical in marginal outline, averaging half a millimetre in length, about one third longer than broad and placed end to end: apertures of the cells nearly terminal, extremely minute, simple and consisting of mere rounded perforations in the cell wall. Surface smooth."

The above description brings out several points showing that the species cannot be a *Stomatopora*. That both the description and figures given by Whiteaves faithfully record the facts can be attested by the senior author of this paper who, in 1890, saw the four specimens upon which the species was shortly thereafter established. At that time the latter failed to recognize the true affinities of the specimens, but now, since we have studied all the known Paleozoic forms of this peculiar type of Bryozoa, we have not the least hesitation in pronouncing *Stomatopora moniliformis* a species of *Allonema*. Specifically it is closely allied to our *A. botelloides*, but differs in the slightly greater average width and more bead-like form of its internodes. The small, subcentral aggregation of vesicles is another feature that may assist in separating the species from the Silurian type of the genus.

**Variety AGGREGATUM new variety**

Under this name we propose to distinguish a variety of *A. moniliforme* that is represented in the Ulrich collection by a single, well-preserved example from the Hamilton formation in Genesee county, New York. It is a patch about 1 cm. in diameter, attached to a small coral, and consists, as may be seen in plate LXVII, 9, of a closely

arranged and somewhat radially disposed series of sharply defined internodes or vesicles. The latter vary greatly in size, both as to width and length, and also in form. Only the larger series project beyond the central or denser part of the colony.

*Occurrence*.—The typical form is from the horizon of *Schizophoria striatula* in the Devonian, on Hay river, Canada, 40 miles above its mouth. Variety *aggregatum* is from the Hamilton formation, in Genesee county, New York.

Cat. No. 43,131, U. S. N. M.

**ALLONEMA WALDRONSENSE** new species

(PLATE LXVII, 5)

Colonies small, consisting of an irregular, winding series of comparatively few and rather large, inflated internodes. The series branches occasionally, and a few of the internodes appear to be quite isolated. The internodes vary greatly in form, some being globular or elliptical, others pyriform, and a few of the largest bilobate. The last probably consist of two partially confluent vesicles. With all this variation, the internodes still remain within reasonable distance of the average size that we consider characteristic of the species. The average length may be placed at about 0.5 mm., the width at 0.3 mm.

So far as the size of the internodes is concerned, they are no larger than in *A. moniliforme* (Whiteaves) and only a little larger than in *A. botelloides*, but their bulbous and irregular shapes and the narrow necks connecting them cause them to look very different. The true affinities of *A. waldronsense* doubtless lie with *A. fusiforme* (Nicholson and Etheridge, Jr.) and our *A. subfusiforme*. It is, however, readily distinguished from both by its smaller internodes.

*Occurrence*.—Waldron shales of the Niagaran group, Waldron, Indiana.

Cat. No. 43,128, U. S. N. M.

**ALLONEMA SUBFUSIFORME** new species

(PLATE LXVII, 6, 7)

Colonies small, of few large internodes, the series branching irregularly. Internodes normally bottle-shaped, with a narrow connecting neck, varying greatly in size, the largest 1.0 mm. in length and 0.6 mm. in width, the smallest only about 0.4 mm. long by 0.22 mm. wide. The largest internodes usually at the distal extremities of the branches, the smallest at the proximal ends. Average size of internodes about 0.7 mm. in length and 0.4 mm. in width.

This species is distinguished from *A. waldronense*, which occupies a nearly equivalent geological horizon in America, only by the larger average size and rather more regular form of its internodes. In the matter of size it agrees more nearly with the Devonian *A. fusiforme* (Nicholson and Etheridge, Jr.), but its internodes are rarely, if ever, isolated, and when normally developed they are bottle-shaped rather than fusiform.

*Occurrence*.—Silurian, Island of Gotland.

Cat. No. 43,127, U. S. N. M.

**ALLONEMA FUSIFORME (Nicholson and Etheridge, Jr.)**

(PLATE LXVII, 8)

1877. *Ascodictyon fusiforme* NICHOLSON AND ETHERIDGE, JR., Ann. & Mag. Nat. Hist., ser. 4, vol. XIX, p. 463, pl. 19, figs. 7, 8.

1892. *Ascodictyon fusiforme* VINE, Proc. Yorkshire Geol. & Polyt. Soc., vol. XII, p. 89.

Plate LXVII, 8, represents the greater part of a very characteristic example of this species. Often many of the internodes or vesicles are quite isolated, but more generally they just touch one or more of their neighbors. The most common shape is fusiform, others ovate, while a greater or smaller number in each colony are joined together by rather long necks. As usual in species of this genus, the whole surface is distinctly punctate, but in no case have we observed a point where an erect zoecium might have been attached.

The principal distinctive features of this species are the frequent isolation of the internodes and their normally fusiform shape.

*Occurrence*.—Hamilton formation, Alpena, Michigan; Falls of the Ohio; Thedford (Widder), Ontario.

Cat. No. 43,129, U. S. N. M.

**ALLONEMA? MINIMUM new species**

(PLATE LXVII, 10-12)

Small colonies consisting of frequently bifurcating series of subglobular, ovate, or more or less elongate pyriform vesicles, generally about 0.1 mm. in width and varying in length, according to the degree in which the proximal end is drawn out, from 0.1 mm. to 0.28 mm. The pyriform cells usually carry a minute pore and remind of the zoecia of Ordovician species of *Stomatopora*, like *S. inflata*. No pores of any kind were observed on the subglobular vesicles. Aside from the single pore that occurs on most of the pear-shaped cells, these also exhibited no trace of the surface punctation observed in all the other species referred to this genus.

We are not satisfied that this neat but very minute species is properly classified, but, as no fitter disposition suggested itself, we trust the arrangement may suffice until increasing knowledge enables us to fix its systematic position definitely.

*Occurrence*.—Upper Coal Measures, Springfield, Illinois.

Cat. No. 43,124, U. S. N. M.

#### Family ASCODICTYONIDÆ Ulrich (restricted)

From the viewpoint of the systematist, perhaps the most notable result of this revision of the Paleozoic Ctenostomata is the restriction of this family to the typical genus. Something of this sort, however, was to be expected, since the classification of these obscure bryozoan remains hitherto in force was always regarded as a most provisional arrangement.

#### Genus ASCODICTYON Nicholson and Etheridge, Jr.

1877. *Ascodictyon* (part) NICHOLSON AND ETHERIDGE, JR., Ann. & Mag. Nat. Hist., ser. 4, XIX, p. 463.  
 1881. *Ascodictyon* VINE, Quart. Jour. Geol. Soc. London, XXXVII, p. 618.  
 1882. *Ascodictyon* VINE, Ibid., XXXVIII, p. 52.  
 1884. *Ascodictyon* VINE, Rep. 53d Meeting Brit. Assoc. Adv. Sci., p. 185.  
 1884. *Ascodictyon* VINE, Ann. & Mag. Nat. Hist., ser. 5, XIV, p. 78.  
 1887. *Ascodictyon* VINE, Proc. Yorkshire Geol. & Polyt. Soc., IX, p. 183.  
 1889. *Ascodictyon* MILLER, North Amer. Geol. and Pal., p. 293.  
 1890. *Ascodictyon* ULRICH, Geol. Surv. Illinois, VIII, p. 367.  
 1892. *Ascodictyon* VINE, Proc. Yorkshire Geol. & Polyt. Soc., XII, p. 86.  
 1897. *Ascodictyon* SIMPSON, Fourteenth Ann. Rep. State Geol. New York for 1894, p. 603.  
 1900. *Ascodictyon* NICKLES AND BASSLER, Bull. U. S. Geol. Surv., No. 173, p. 19.

Zoaria parasitic, consisting of ovate or pyriform vesicles, arranged in radial clusters or isolated, and connected with each other by very delicate, hollow threads. Walls of vesicles perforated by closely arranged, minute pores. Zoecia unknown.

*Genotype*.—*A. stellatum* Nicholson and Etheridge, Jr.

Although *A. fusiforme* follows the generic description in the original publication, and for that reason is usually cited by cataloguers as the genotype, it is very evident that the authors of the genus regarded *A. stellatum* as the type. This is shown by the italicized words in the following quotation from their generic diagnosis: "In some cases they [the vesicles] open into one another by short contracted necks or stolons, thus forming a loosely reticulate network; whilst *more typically* they are arranged in regular, usually stellate clusters, which in turn are united with one another by delicate thread-like hollow

tubes, which often ramify and anastomose." The matter of selecting and fixing the genotype is important for the reason that we refer *A. fusiforme* to our new genus *Allonema*, while Nicholson and Etheridge's third species, *A. radians*, is removed provisionally to *Vinella*.

The restriction of *Ascodictyon* to species agreeing strictly with the adopted type *A. stellatum*, renders it a compact and sharply defined genus. As now constituted, the only amendment still possibly defensible is the elimination of *A. filiforme* Vine and *A. sparsum*, one of our new species, in which the vesicles, if we leave the connecting threads out of consideration, are always isolated. In all the other species they are normally arranged in radial clusters. If it could be shown that this difference in the arrangement of the vesicles is of genetic significance, we should be strongly inclined to favor a separation. At present, however, we have no direct evidence bearing upon the point and must, therefore, regard the future restriction of the genus as unjustifiable. It may be worthy of remark, however, that even in *A. stellatum* at least some of the vesicles of many colonies are isolated or, rather, scattered without definite relation to each other.

So far as known, the first species of this genus occur in the Silurian, *A. siluriense* Vine being found, together with *A. filiforme* Vine, in the Wenlock shales of England, and the former species also in the Rochester and Waldron shales of this country. The shales of the Hamilton formation also afford two species, the genotype *A. stellatum* and a new form for which we propose the name *A. floreale*. The shales of the Chester group is the third and last horizon in which we have detected the genus, and, as in the two preceding cases, here again it is represented by two species, both new.

#### ASCODICTYON SILURIENSE Vine

(PLATE LXVIII, 11, 12)

1881. *Ascodictyon stellatum* VINE, Quart. Jour. Geol. Soc. London, xxxvii, p. 618.  
 1882. *Ascodictyon stellatum* var. *siluriense* VINE, Ibid., xxxviii, p. 52, figs. 1, 2.  
 1884. *Ascodictyon stellatum* var. *siluriense* VINE, Ann. & Mag. Nat. Hist., ser. 5, xiv, p. 81.  
 1887. *Ascodictyon stellatum* var. *siluriense* VINE, Proc. Yorkshire Geol. and Polyt. Soc., ix, p. 184, pl. 12, fig. 6.  
 1892. *Ascodictyon siluriense* VINE, Ibid., xii, p. 88, pl. 2, fig. 1.

Vesicles pyriform, the small end more or less drawn out, 0.1 mm. to 0.2 mm. in diameter, and 0.3 mm. to 0.5 mm. in length, arranged



in clusters of four to eight, with clusters of four or five occurring oftener than six to eight. Connecting threads about 0.03 mm. in thickness, comparatively straight, with clusters of vesicles occurring at intervals of 2.5 mm. or more.

Compared with *A. stellatum*, this species is distinguished by its usually fewer and less closely arranged vesicles in each cluster, by the greater average length and more pyriform shape of the vesicles, and by the comparative rigidity of the connecting threads.

*Occurrence*.—Wenlock shale, Buildwas beds, Shropshire, England; Rochester shale, Lockport, New York; Waldron shale, Waldron, Indiana.

Cat. Nos. 43,135, 43,138, U. S. N. M.

#### ASCODICTYON STELLATUM Nicholson and Etheridge, Jr.

(PLATE LXVIII, 9, 10)

1877. *Ascodictyon stellatum* NICHOLSON AND ETHERIDGE, JR., Ann. & Mag. Nat. Hist., ser. 4, XIX, p. 464, pl. 19, figs. 1-6.

1891. *Ascodictyon stellatum* WHITEAVES, Contr. Canadian Pal., I, p. 213.

1892. *Ascodictyon stellatum* VINE, Proc. Yorkshire Geol. & Polyt. Soc., XIX, p. 89.

1893. *Ascodictyon stellatum* ULRICH, Geol. Minnesota, III, p. 113, fig. 8a.

1897. *Ascodictyum stellatum* SIMPSON, Fourteenth Ann. Rep. State Geol. N. Y. for 1894, p. 603, fig. 220.

Not *Ascodictyon stellatum* VINE, 1881 (= *Ascodictyon siluriense* VINE).

*Original description*.—"Colony composed of ovoid or pyriform calcareous vesicles, varying in length from one fifth to one third of a line, and usually disposed in stellate clusters, each containing from three to six cells, or sometimes more. The walls of the vesicles are perforated by microscopic foramina, usually showing a distinctly linear arrangement. The clusters are connected together by creeping filamentous tubes, the free surfaces of which are perforated by a single row of minute foramina, and which generally anastomose so as to form a network."

This common and widely distributed species maintains its specific characters with great constancy. Still, it agrees too closely with certain specimens of *A. siluriense* to render their separation always easy. As a rule the Silurian species has fewer vesicles in its clusters, and these generally occur also at longer intervals. Again the inner ends of the vesicles are never drawn out in *A. stellatum* as is common in *A. siluriense*. Finally, in a close comparison, the connecting threads impress one as being less rigid in the Devonian species than in the older form.

*Occurrence*.—Hamilton formation, Eighteen Mile creek and other localities in New York; Thedford (Widder) and neighboring localities in Ontario.

Cat. No. 43,137, U. S. N. M.

**ASCODICTYON FLOREALE** new species

(PLATE LXVIII, 13)

Though easily distinguished from *A. stellatum*, this species differs in little or nothing save that it is considerably smaller. The average width of the flower-like clusters is only about 0.5 mm. while in *A. stellatum* they usually reach a diameter of nearly 1.0 mm. The clusters occur also at shorter intervals in *A. floreale*, the average distance from center to center being less than 1.0 mm. With specimens in hand these differences cannot fail to strike the observer at once.

*Occurrence*.—Hamilton formation, 2 miles west of Alpena, Michigan.

Cat. No. 43,136, U. S. N. M.

**ASCODICTYON PARVULUM** new species

(PLATE LXVIII, 14)

This species is characterized by its extreme minuteness and crowded habit of growth. Five to eight vesicles occur in each cluster, but in parts of the colonies they appear to be arranged without regard to any central point or points. As a rule these irregularly disposed vesicles are of less than the average size. Generally the clusters are less than 0.5 mm. apart, measuring from center to center. The vesicles are elliptical or pyriform in outline, and vary in length from 0.07 mm. to 0.12 mm.

*Occurrence*.—Chester group, Jackson county, Kentucky.

Cat. No. 43,143, U. S. N. M.

**ASCODICTYON FILIFORME** Vine

(Not figured)

1882. *Ascodictyon filiforme* VINE, Quart. Jour. Geol. Soc. London, xxxviii, pp. 54-55.

1894. *Ascodictyon filiforme* VINE, Ann. & Mag. Nat. Hist., ser. 5, xiv, pp. 78-80.

1887. *Ascodictyon filiforme* VINE, Proc. Yorkshire Geol. & Polyt. Soc., ix, p. 183, pl. 12, figs. 1-4.

1892. *Ascodictyon filiforme* VINE, Ibid., xii, p. 86, pl. iii, figs. 8-15.

Vesicles not occurring in regular clusters, as in the more typical species of the genus, but developed at very unequal though generally short intervals from the sides of the connecting threads; occasionally

developed abundantly enough to simulate the radial clusters of the other species. Vesicles apparently of slightly smaller average size than in the associated *A. siluriense* of the same author.

*Occurrence*.—Buildwas beds, Wenlock shales, Shropshire, England.

**ASCODICTYON SPARSUM** new species

(PLATE LXVIII, 15)

This species is founded upon a single, but excellently preserved, colony attached to a species of *Polypora*. The vesicles contrast strongly with the host, being much darker—nearly black. In form they are ovate, appearing as highly inflated bulbs lying close to, in some instances apparently in contact with, one of the extremely fine threads that run in every direction over the surface of the *Polypora*, though mostly parallel with the length of its branches. Generally the vesicles are solitary; sometimes, however, they occur in pairs, while the interval between them is often greater than shown in our figure. In size they vary from 0.1 mm. by 0.15 mm. to 0.2 mm. by 0.25 mm.

Belonging to the section of the genus having solitary vesicles, this species need only be compared with Vine's *A. filiforme*. From this it is readily distinguished by the smaller size of its vesicles and greater delicacy of its connecting threads.

*Occurrence*.—Near top of Chester group, Claxton, Caldwell county, Ky.

Cat. No. 43,142, U. S. N. M.

**ASCODICTYON YOUNGI** Vine

(Not figured)

1892. *Ascodictyon Youngi* VINE, Proc. Yorkshire Geol. & Polyt. Soc., XII, p. 90, pl. 4, figs. 3, 4.

*Original description*.—"Zoarium composed of pyriform vesicles occasionally disposed in stellate cluster, similar to other species already described. These vesicles are connected together by filamentous, hollow, unornamented threads, which creep along and undulate with the irregularities of the surfaces to which the forms are attached. The type species is adherent to a portion of a Crinoid stem (*Platycrinus* sp.), and the stellate vesicles are not so abundant in their colonial growths as in the Silurian species."

*Occurrence*.—Carboniferous shales, Hairmyres, Scotland.

*Position Doubtful*

Genus **PTYCHOCLADIA** new genus

Parasitic, small patches, consisting of bifurcating and inosculating, transversely wrinkled, minute branches.

*Genotype and only known species.*—*Ptychocladia agellus* new species.

PTYCHOCLADIA AGELLUS new species

(PLATE LXVII, 10 (part), 13)

Beginning with a comparatively strong, curved stem, 0.2 mm. to 0.5 mm. in width, the colony continues its growth by addition of frequently dividing and coalescing depressed convex branches which increase in width from 0.1 mm. to 0.2 mm. or more, until an irregularly cribose expansion, 3.0 mm. to 5.50 mm. in width, is produced. Basal stem and branches with transverse wrinkles, apparently composed of structureless, cemented, calcareous grains, which occasionally appear to have been combined so as to leave minute pores between them.

The minute structure of these fossils is very obscure, and their systematic position so doubtful that we are scarcely willing to hazard an opinion. Possibly they are algæ, or, if their branches are tubular, a point we did not succeed in determining, they may be related to some of the preceding forms. Again, they may prove to belong to some peculiar type of Foraminifera. Of these various possibilities, the first strikes us as the most plausible, though we are not by any means prepared to express a decided opinion.

*Occurrence.*—Upper Coal Measures, near Springfield, Ill. Associated with *Allonema* ? *minutum*.

Cat. No. 43,123, U. S. N. M.

EXPLANATION OF PLATES

PLATE LXV

(With the exception of figures 11 to 13, all of the illustrations on this plate were reproduced from rather crude tracings of previously published figures, and reduced one-third in the reproduction. Figures 1 to 8 are of recent species from Hincks' *British Marine Polyzoa*, figures 9 and 10 from Nicholson and Etheridge's work on *Ascodictyon*, and figure 14 from a paper by Whiteaves.)

- FIG. 1. *Ætea anguina* Linnæus. Showing zoœcia arising from the creeping stem,  $\times 16$ .
2. *Ætea truncata* (Landsborough). A portion of the creeping base,  $\times 16$ .  
(Figures 1 and 2 are introduced for comparison with *Allonema* and *Rhopalonaria*).
3. *Cylindracium dilatatum* Hincks,  $\times 16$ .
4. 5. *Vesicularia spinosa* Linnæus,  $\times 16$  and  $\times 28$ , to be compared with *Vinella* and *Heteronema*. Figure 4 represents the terminal portion of a branch from which most of the zoœcia have been stripped.
6. *Valkeria uva* Linnæus. Erect form,  $\times 16$ , *Allonema* and *Ascodictyon* are to be compared with this genus.

7. *Arachnidium clavatum* Hincks,  $\times 16$ , showing similarity to *Rhopalonia*.
8. *Bowerbankia caudata* (Hincks),  $\times 16$ , exhibiting arrangement of the deciduous zoecia on the stolon.  
*Vinella ? radians* (Nicholson and Etheridge, Jr.).....p. 276
9. Colony, two-thirds natural size.
10. A nucleus with the radiating stolons,  $\times 20$ .  
Carboniferous of England.  
*Heteronema capillare* genus and species new.....p. 278
11. Small part of a large colony,  $\times 9$ , growing upon a strophomenoid shell. The threads sometimes cross each other, simulating the nucleus of a *Vinella*, while other threads appear to be jointed.  
Silurian, Island of Gotland.  
*Heteronema ? contextum* new species.....p. 279
12. Small part of a large colony,  $\times 9$ , growing over the celluliferous face of a monticuliporoid bryozoan.  
Corryville beds, Lorraine formation, Morrow, Ohio.  
*Heteronema carbonarium* new species.....p. 279
13. Several of the creeping threads,  $\times 9$ , growing upon a *Spirifer*.  
Lower Coal Measures, Seville, Ill.  
*Allonema moniliforme* (Whiteaves).....p. 282
14. A colony,  $\times 6\frac{2}{3}$ .  
Devonian, Hay river, Canada.

## PLATE LXVI

(Unless otherwise mentioned, the figures on this plate are  $\times 9$ .)

- Arachnidium hippothoides* Hincks .....p. 263
- FIG. 1. Outline sketch of several zoecia of this living species,  $\times 16$ , introduced for comparison with species of *Rhopalonia*. (After Hincks, *British Marine Polyzoa*).
- Rhopalonia venosa* Ulrich.....p. 268
2. Portion of the reticulate zoarium of this species growing upon a pelecypod. The substance of the zoarium is replaced by pyrites.
  3. Part of a colony with broader zoecia than usual, encrusting *Rafinesquina alternata*.  
Lower beds of Richmond formation, Waynesville, Ohio.  
*Rhopalonia attenuata* new species.....p. 269
  4. Part of a colony preserved as an excavated mold, with several branches growing so as to intersect each other, thus causing an apparent irregularity in the growth.
  5. Portion of another colony preserved as an excavated mold on a gastropod, showing a more regular arrangement of the zoecia. Both figures illustrate the extreme tenuity of the connecting stolons and the very slight swelling of the zoecial part.  
Rochester shales, Lockport, New York.  
*Rhopalonia robusta* new species.....p. 269
  6. The greater part of a colony illustrating the comparatively large size and general form of the zoecia.  
Oriskany (Camden chert), Camden, Tennessee.

- Rhopalonaria tenuis* new species.....p. 270
7. Portion of a colony growing on a *Strophodonta* and showing a rather irregular growth and the attenuate fusiform shape of the zoëcia.  
Hamilton formation, Thedford, Ontario.
  8. The excavated mold of a normally developed colony.
  9. The excavated mold of another colony in which the zoëcia are crowded on account of the frequent crossing of the branches. Doubtfully referred to this species.  
Hamilton formation, Alpena, Michigan.  
*Rhopalonaria medialis* new species.....p. 270
  10. Portion of a colony attached to the same shell bearing the specimen illustrated by figure 7.  
Hamilton formation, Thedford, Ontario.  
*Rhopalonaria keokukensis* new species.....p. 272
  11. Portion of a large colony of which the excavated mold only is preserved, covering the greater part of a *Zaphrentis*.  
Keokuk formation, Keokuk, Iowa.

## PLATE LXVII

(Unless otherwise specified, the figures on this plate are  $\times 9$ .)

- Allonema botellus* (Vine).....p. 281
- FIG. 1. Portion of a colony attached to the dorsal valve of *Leptæna rhomboidalis*.  
Silurian, Island of Gotland.
- Allonema botelloides* new species.....p. 281
- 2, 3. Portions of two colonies, one growing upon *Goniophyllum pyramidatum* and the other upon a cyathophylloid coral.
  4. One of the vesicles of figure 3,  $\times 18$ , showing a pore or pit near one end and the small pores of the test.  
Silurian, Island of Gotland.  
*Allonema waldronense* new species.....p. 283
  5. Portion of a colony attached to the dorsal valve of an orthoid.  
Waldron shales, Waldron, Indiana.  
*Allonema subfusiforme* new species.....p. 283
  6. The greater part of a colony attached to *Goniophyllum pyramidatum*.
  7. One of the vesicles of same,  $\times 18$ , showing the punctate surface.  
Silurian, Island of Gotland.  
*Allonema fusiforme* (Nicholson and Etheridge, Jr.).....p. 284
  8. A small part of a colony. Only one vesicle is drawn to show the punctæ of the surface. The specimen is growing upon the poriferous side of a small *Polypora*.  
Hamilton formation, Alpena, Michigan.  
*Allonema moniliforme* var. *aggregatum* new variety.....p. 282
  9. Portion of a colony growing upon a *Diphyphyllum*. The figure shows the close arrangement of the rows of vesicles.  
Hamilton formation, Genesee county, New York.  
*Allonema ? minimum* new species.....p. 284
  10. The greater part of a colony with a young specimen of *Ptychocladia agellus* running from the lower to the middle part of the figure.
  11. A series of vesicles of same,  $\times 18$ , showing variations in form and the aperture-like pit in four of them.

12. Another series of the same,  $\times 18$ , showing further variations in form of the vesicles.  
Upper Coal Measures, Springfield, Illinois.  
*Ptychocladia agellus* new genus and species.....p. 290
13. The most complete of the specimens upon which this remarkable genus and species is founded. See also figure 10.  
Upper Coal Measures, Springfield, Illinois.

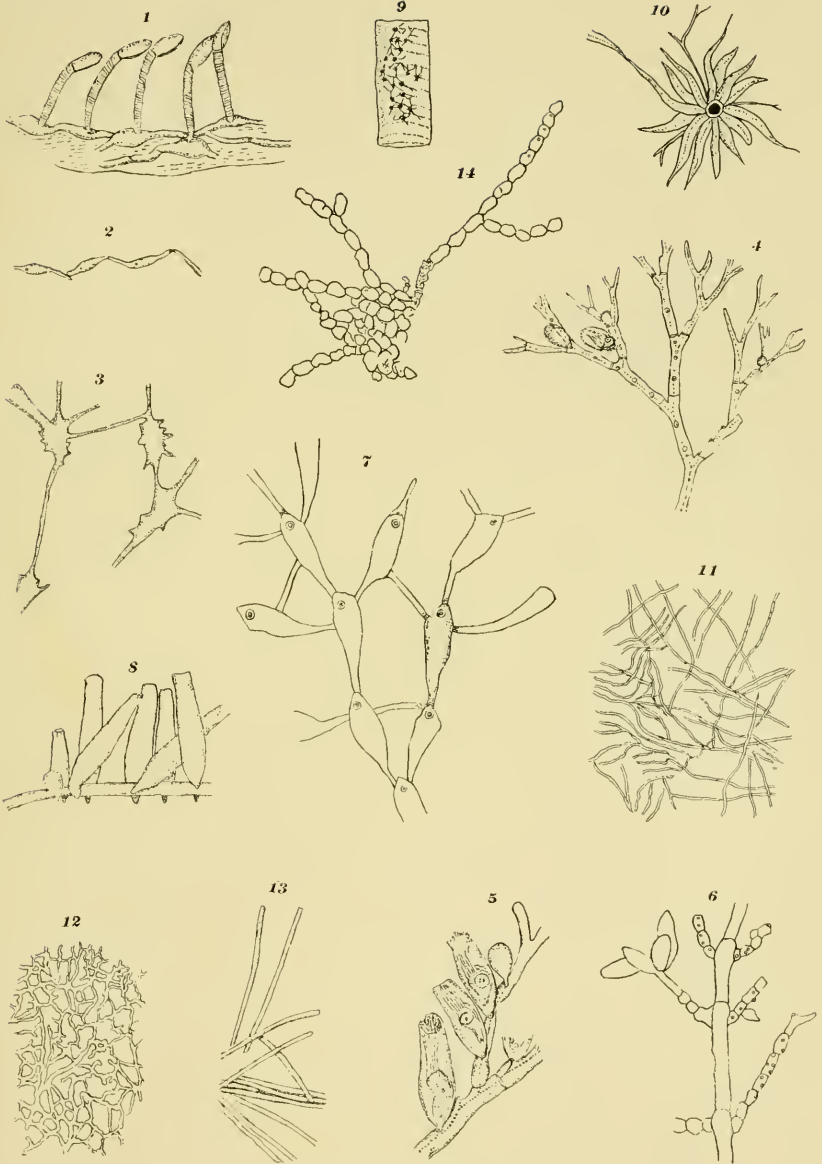
## PLATE LXVIII

(Figures 1 to 6 and 9 are after Ulrich in Pal. Minn., III, Pt. 1.)

- Vinella repens* Ulrich.....p. 274
- FIG. 1. Two colonies attached to the inner side of a ventral valve of *Strophomena septata* W. & S.; natural size.
2. Portion of one of the colonies,  $\times 18$ .
3. Another portion of the same zoarium,  $\times 18$ , showing a nucleus with five divisions of the tubular stolons radiating from it.  
Black River shales, St. Paul, Minn.  
*Vinella radialis* Ulrich.....p. 274
4. Natural size view of the type specimen.  
Corryville beds, Lorraine formation, Cincinnati, Ohio.  
*Vinella radiformis conferta* Ulrich.....p. 275
5. Several nuclei and the connecting stolons,  $\times 18$ .
6. Part of a colony,  $\times 4\frac{1}{2}$ , showing the close development of the nuclei.  
Waldron shales, Waldron, Indiana.  
*Vinella radiformis* (Vine).....p. 275
7. Portion of the creeping network of the typical form of this species,  $\times 9$ , showing several nuclei.  
Rochester shales, Lockport, New York.  
*Vinella?* *multiradiata* new species.....p. 276
8. Part of a colony attached to a crinoid column, exhibiting many nuclei and the intertwining of the numerous radiating stolons,  $\times 9$ .  
Rochester shales, Lockport, New York.  
*Ascodictyon stellatum* Nicholson and Etheridge, Jr.....p. 287
- 9, 10. Two clusters,  $\times 18$  and  $\times 9$ . Only one of the vesicles in the first figure has the surface punctæ represented.  
Hamilton formation, Eighteen Mile creek, New York.  
*Ascodictyon siluricense* Vine.....p. 286
11. Two isolated clusters of vesicles,  $\times 9$ , attached to a fragment of *Leptæna rhomboidalis*.  
Rochester shales, Lockport, New York.
12. A number of clusters of vesicles with connecting stolons,  $\times 9$ , growing on a small *Orthoceras*.  
Waldron shales, Waldron, Indiana.  
*Ascodictyon florale* new species.....p. 288
13. Portion of a colony with numerous clusters of vesicles,  $\times 9$ , growing upon a *Stropheodonta*.  
Hamilton formation, 2 miles west of Alpena, Michigan.

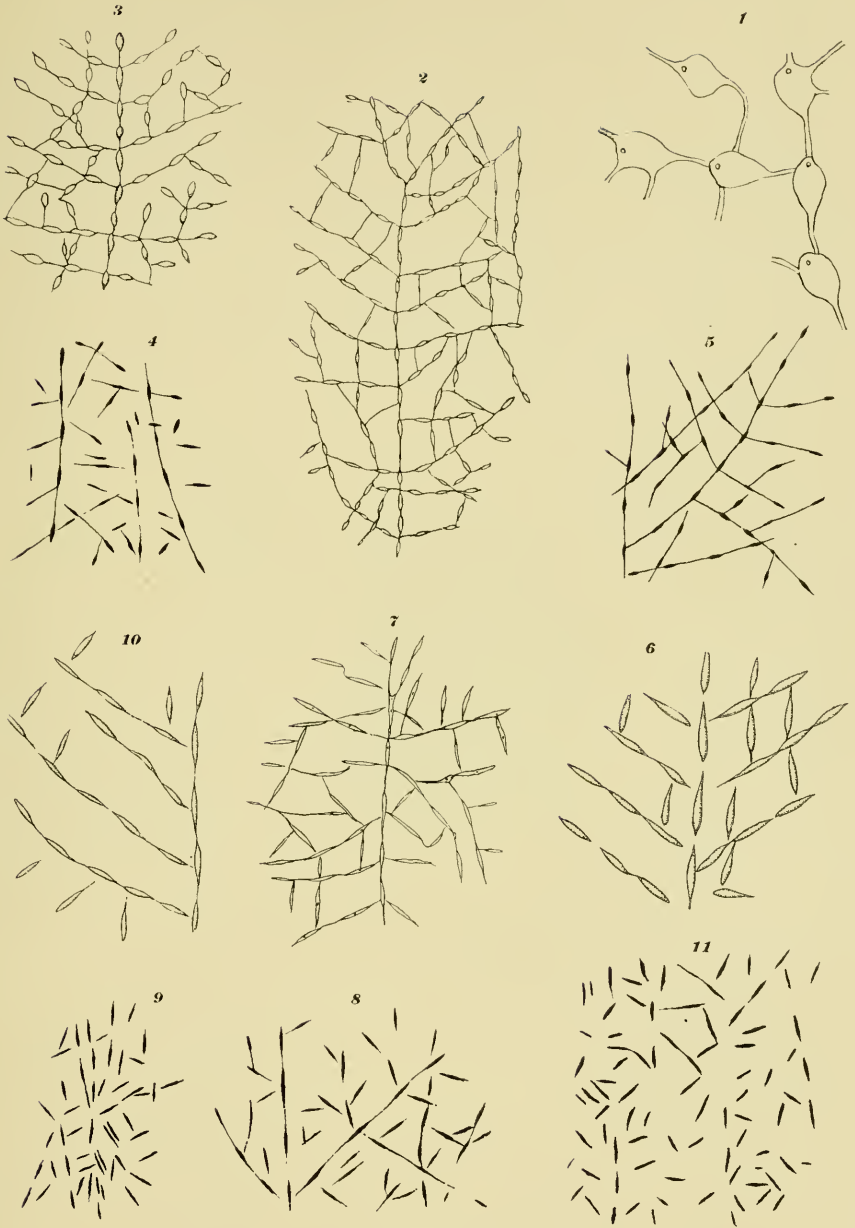
- Ascodictyon parvulum* new species.....p. 288
14. Part of a colony,  $\times 9$ , growing upon a crinoid column, showing vesicles arranged in clusters and others apparently without order.  
Chester formation, Jackson county, Kentucky.
- Ascodictyon sparsum* new species.....p. 289
15. Several branches of the adnate colony, showing the usual scattered arrangement of the vesicles,  $\times 9$ . The connecting stolons are not so clearly shown in the specimen as in the figure.  
Chester formation, Claxton, Caldwell county, Kentucky.





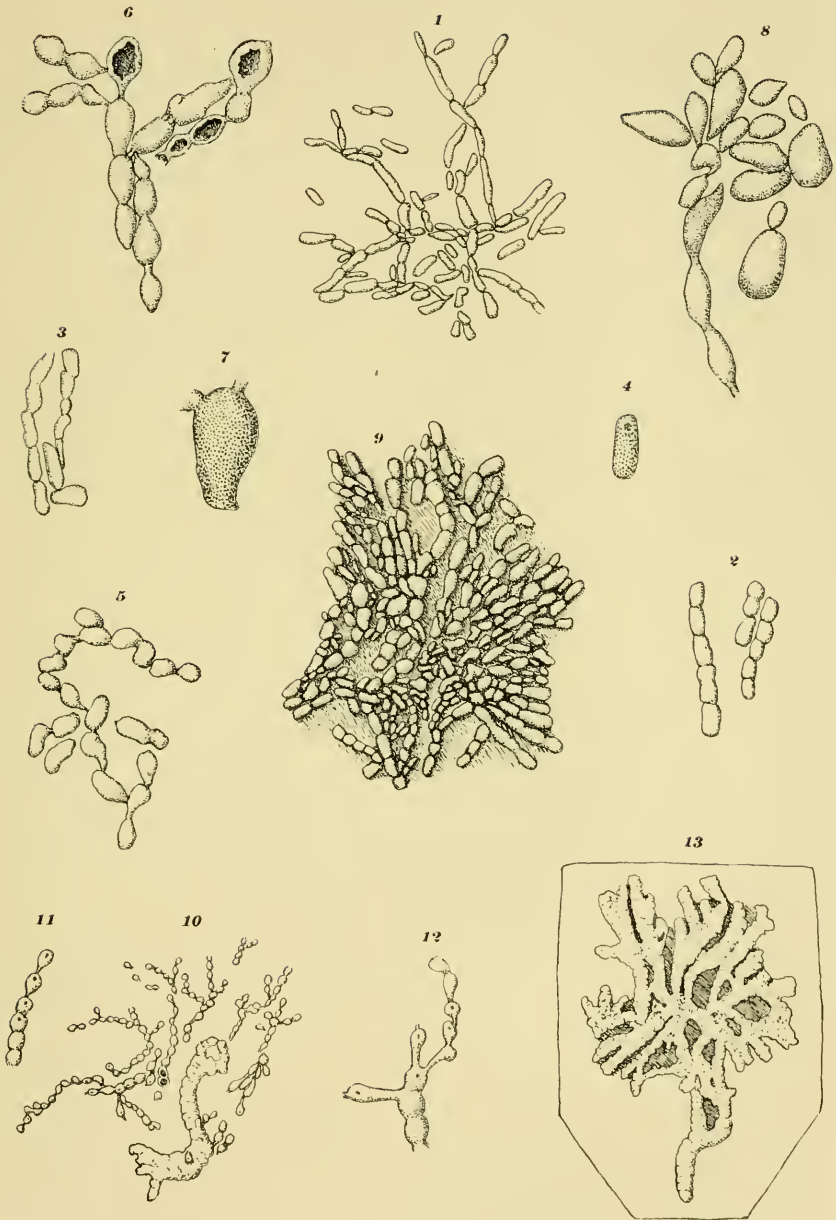
SPECIES OF CTENOSTOMATA.





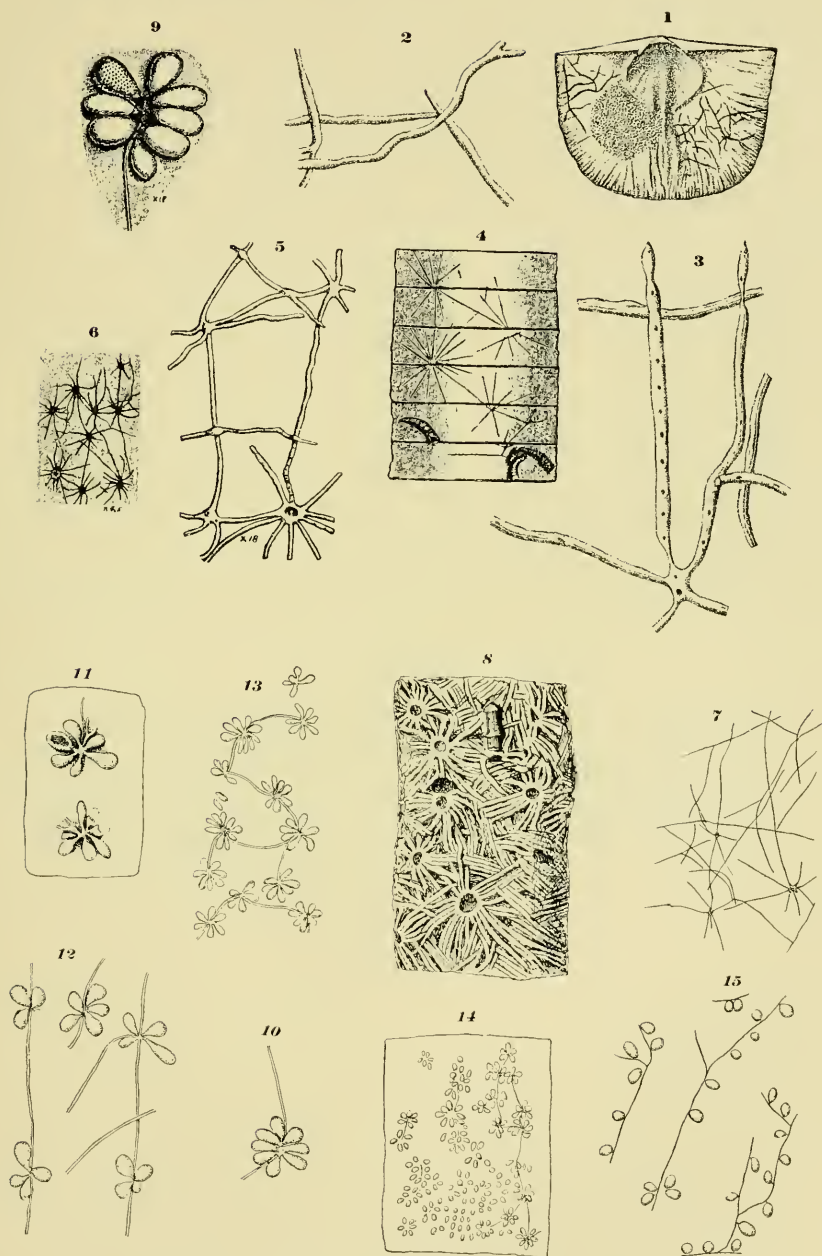
SPECIES OF CTENOSTOMATA.





SPECIES OF CTENOSTOMATA.





SPECIES OF CTENOSTOMATA.





## A REMARKABLE GENUS OF FISHES—THE UMBRAS

By THEODORE GILL

### I

In 1726 Marsigli, in a volume on fishes in a series entitled *Danubius Pannonico-Mysicus* (tom. iv), for the first time described in a recognizable manner a small fish of lower Austria which was known to watermen as the Hundsfisch (dogfish) and which he called *Gobius caninus*. He likened it to the Cyprinid named gudgeon (with which indeed many watermen confounded it), and hence the name he gave it, *Gobius* being his Latin name for the gudgeon. That name was not applied in the spirit of the modern binomial system of nomenclature and consequently has not been adopted by modern naturalists. He indicated that the little fish lives in stagnant

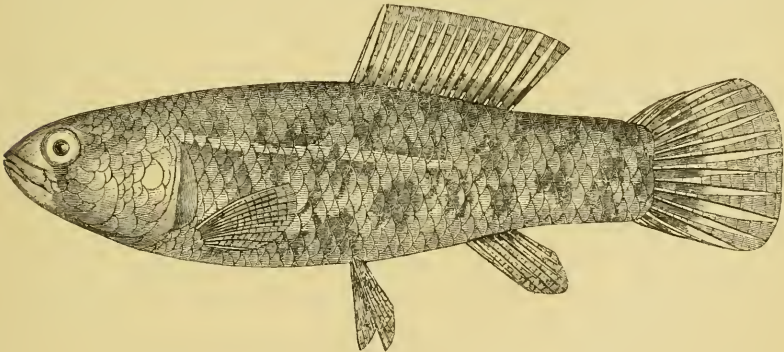


FIG. 34.—European Umbra (*Umbra umbra*). After Heckel and Kner.

waters and in caves, and that it is rarely seen; it is observed mostly in spring when it is carried by freshets into more frequented waters.

In 1756 W. H. Kramer, in an *Elenchus Vegetabilium et Animalium per Austriam inferiorem observatorum*, described the same fish as found in affluents of the Danube and caves in lower Austria, and he named it *Umbra*; the name was given as a generic term after a consideration and comparison of the genera of Artedi. The name was given because the species harbored mostly in grottoes where the light does not penetrate and consequently lived in the shade (*umbra*).

In 1777 J. J. Scopoli accepted the name *Umbra* as a generic designation and referred it to his second order (ordo 2.), distinguished by the subcylindrical body (*corpore tereti aut teretiusculo*). He interposed it between the genera *Esox* and *Albula* on the one hand and *Cobitis* and *Anableps* on the other. His diagnosis was equally applicable to almost all Cyprinodonts and doubtless, if the author had known such, he would have referred them to the same genus.<sup>1</sup> As it was, having adopted the genus from Kramer, the species described by Kramer was evidently the type.

By all later authors the type was overlooked or referred to the genus *Cyprinodon* and not till 1842 was it properly recognized. Then the illustrious Johannes Müller found that it was a very distinct genus and related not to the Cyprinodonts but to the pikes with which he associated it in the same family. A few years afterward (1846) Valenciennes proposed to isolate it as the sole representative of a peculiar family to which he only gave the name "Les Ombres (*Umbra*)" in common with the genus. He thought it was most nearly related to the Amias, from which it differed mainly in the absence of the suborbital cuirass (*cuirasse sous-orbitaire*) and the lingual bone; the simple non-cellular air-bladder further distinguishes it. Consequently he believed it was the type of a distinct family (le type d'une famille distincte) which he proceeded to define.

No representatives were recognized from America until near the close of the first half of the nineteenth century, and then several observers at nearly the same time obtained and described specimens from different localities. Jared Kirtland, in 1840, described one form under the name *Hydrargyra limi* from individuals obtained in northern Ohio; Zadock Thompson, in 1842, found the same species in Lake Champlain, and, failing to recognize it as the same as Kirtland's, gave a new name—*Hydrargyra fusca*—to it; in the same year (1842) James E. DeKay gave a new name (*Hydrargyra atricauda*) to the fish first described by Thompson, and having obtained from Rockland county, New York, small specimens of another species, he gave to the latter the name *Leuciscus pygmæus*. None of these authors recognized the relations of the new forms; they all, however, appreciated the likeness to the Cyprinodonts which actually exists, although the fishes really belong to a different family, while the last (DeKay) committed in one case an incomprehensible blunder, inasmuch as his *Leuciscus pygmæus* had none of the essential char-

<sup>1</sup> 256 *Umbra*, *Kramer*. Maxilla inferior longior. Dentes in maxillis. Caput et Abdomen *Cyprini*. Membrana Branch. oss. (6). Pinnæ inermes (7). *Scopoli* Introd. Hist. Nat., p. 450, 1777.

acters he assigned to the genus *Leuciscus* or that truly define the family of Cyprinids.

It was not till 1855 that the true relations of the American fishes were partially recognized. Two years previously (1853) Louis Agassiz had, indeed, referred to "*Charaxini* [*Characini*]" without adipose fin of I. [J.] Müller, of which a new genus occurs in the fresh waters of our northern and middle as well as western states, with a half a dozen species some of which," he continues, "have been unfortunately described as *Leuciscus*, *Fundulus* and *Hydrargyra*, with which genera they have no affinity, while other new ones have been described by Professor Baird and myself." He concludes: "I shall call this genus *Melanura*, from the singular black mark which all species show on the tail." Such is all the information communicated respecting the new genus, and no one could be certain what species were meant. But in 1855 Agassiz interposed a "Note on *Melanura* Agass." in a "Synopsis of the Ichthyological Fauna of the Pacific Slope of North America," affirmed that *Melanura* is the North American representative of the European *Umbra*, specified the species he would refer to it, and gave a diagnosis of it. The diagnosis contained no characteristic differentiating it from *Umbra*. It was regarded by Günther in 1866 as identical with it, and such is now the opinion of all ichthyologists.

In 1866 A. Günther gave the name Umbridae to the family recognized by Valenciennes twenty years before and referred all the American forms, under one specific name (*Umbra limi*), to the same genus as the European fish (*Umbra crameri*). The best idea of their relationship may be conveyed by the statement that they are Pikes in the guise of Killiefishes. They have scales with a peculiar ornamentation or structure, and these extend over the head, leaving only the snout and jaws naked (figures 35, 36).



FIG. 35.—Scale of *Umbra*.



FIG. 36.—Head of *Umbra*, from above.

## II

The results of investigations thus summarized may be summed up in a few words.

The Umbrids or mud minnows are a feeble family represented by a single genus whose species are distributed in a notable manner. A single one (*Umbra umbra* or *krameri*) occurs in central and southeastern Europe, Hungary and the neighboring countries, and two others are inhabitants of the eastern slope of the American continent and the Mississippi valley, while all the intervening countries are deprived of them. They are scarcely distinct from the pikes and, as in them, the supramaxillaries form the lateral margins of the mouth, but the jaws are not produced and the teeth are all small and "villiform." In appearance, indeed, they are much more like Cyprinodonts (killiefishes) than pikes. The species chiefly frequent still waters and are most at home in muddy and reedy ponds or in clear ponds with a muddy bottom; they are also prone to resort to sequestered pools or caverns. They hide on or rather in the bottom, and where not one may be seen at first, numbers may be secured by drawing a net over the bottom and stirring up the mud. They are very tenacious of life and individuals have been kept by the writer for many months without change of water in moderate sized jars with water plants. Their behavior and carriage are characteristic and have been especially described by a number of naturalists, especially by Heckel and Kner (1858), C. C. Abbott (1884), and L. Kathariner (1899).

### III

From authors already cited and from personal observations a tolerable biography may be obtained and the tale is of considerable interest.

In a clear pool some may be seen, if quietly approached, in mid-water, perfectly motionless, with the pectoral fins closed and stretched out and downward, at right angles to the trunk, and with the tips curved slightly forward, while all the other fins (including the ventral) are widely expanded; so they may remain for minutes at a time or with a slight movement of dorsal rays; then one pectoral may be expanded and its surface displayed forward and backward while the other fin may be appressed to the side. Another attitude often assumed is one of balancing in midwater, when sometimes a vertical position is taken, or even the back is inclined downward; the pectorals are then the principal fins used and are constantly moving in an undulatory manner, the fully expanded ones being for a moment outspread and horizontal to the length. Still another frequently assumed attitude is a "statue-like" one which has been also designated by Abbott as the "salamandrine position," and which is often maintained for several minutes at a time. "The body is frequently

curved when at rest, and remains so, the head being turned to the right or left, and the tail in the opposite direction. No one can fail to see the salamandrine appearance of this fish when it assumes such a position." The use of the pectoral and ventrals in such a state of

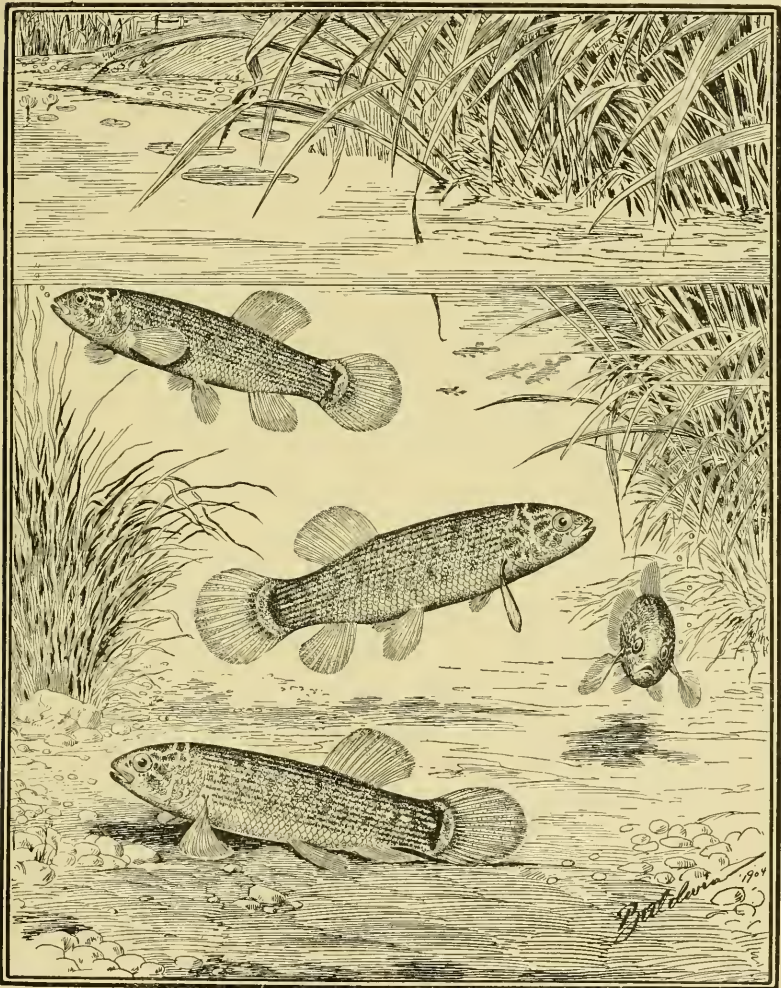


FIG. 37.—Various attitudes of Umbra. After life.

rest has been also likened by Kathariner to that manifested by the "salamandroid" or "sirenoidean" lungfish of Australia named *Neoceratodus*. The pectorals, he declared, are completely turned downward and perpendicular, and their ends, resting on the bottom, in consequence of the weight of the body are twisted outward and

backward; the ventrals are also extended downward and touch the bottom quite lightly. The body rests nearly parallel with the ground, and the caudal is somewhat upraised from the bottom, and the pectorals and ventrals can be used as props for the body. Heckel and Kner have remarked of the European species, that even when the fish remains still or floats, the last three or four rays of the very erect dorsal are alone in a constantly oscillating motion. And, strange to say, they add, the fishes remain thus at rest often for hours at a time, now in a horizontal, now in a vertical position, with the head turned either upward or downward. Then suddenly they all dart from the bottom to the surface with a quick movement of the tail, gasp for air, emit it again in diving as large bubbles through the gill-opening, and for some time afterward breathe very slowly. Heckel and Kner also remarked on their peculiar movements when swimming. The pectorals and ventrals are moved alternately, like the feet of a dog running, and the dorsal makes a quick wavy motion with all its rays, the like of which is seen in seahorses and pipefishes (*Hippocampus* and *Syngnathus*), which is effected by a peculiar disposition of individual muscles for the various rays of the fin.

But most of their life is spent at the bottom, and when a clear pool reveals no evidence of their existence, a little stirring up of the bottom may bring many to view. "On disturbing them, occasionally, instead of swimming, especially if the water is very shallow, they make a forward movement, by giving these fins a leg-like motion, indicated by leaving faint traces, thus: ( ( ( ( ( ( upon the sand." But it is also "often a voluntary movement on their part," and, in fact, "if suddenly disturbed, they generally dart off by swimming only, and bury themselves, tail-foremost, in the mud." They are perfectly at home there and Abbott claims that they "can pass through soft mud with as much ease [not quite!] as other fishes do through the clear waters." They are mostly carnivorous and do not appear to manifest any special preference for anything that is of the flesh, but their capacity is limited by their own size and that of their mouth. In a state of nature, they feed largely upon the aquatic larvæ of insects as well as crustaceans, and the eggs of fishes as well as young and small fishes. They also make excursions from the water in search of insects. "Unlike any other of our fishes," Abbott asserted, "the mud-minnow will leap twice and thrice its length above the surface of the water to seize a fly or beetle that happens to rest upon some overhanging blade of grass or twig." But, although mostly carnivorous, they are not entirely so, as has been asserted. Forbes (1883), indeed, found that, in the "mud

minnow" (*Umbra limi*) of Illinois, "vegetable food amounted to forty percent, chiefly *Wolffia*" (an aquatic lemnaceous plant), and "a considerable quantity of unicellular algæ was also taken by one; mollusks, eaten by two, were reckoned at five percent, all Physa; insects drop to fourteen percent, chiefly undetermined larvæ. No terrestrial forms were recognized. Corresponding to the greater development of the gill-rakers, we find the Entomostraca assuming greater importance in the food. These were reckoned at ten percent; three percent additional consisting of *Crangonyx gracilis*," a small amphipod crustacean. Five specimens of the *Umbra limi* obtained from a pond, "covered in September with a film of *Wolffia* and other vegetation," yielded to the dissector stomach contents consisting of sixty percent of the *Wolffia*; of the remainder "about one-fourth consisting of Entomostraca" and the rest of "unrecognized insects."

In captivity they will readily take small shreds of meat as well as their natural food. "When kept in aquaria they will devour any reasonable number of flies offered them, and undertake without hesitation to swallow earth-worms as large as themselves. Once they take hold of a worm, they never let go, but at least secure that portion of the animal between their jaws. Not only do they allow themselves to be fed, but they will leap above the water to seize any tempting morsel held above them." Long ago (1842) Zadock Thompson was struck by their power of accommodating themselves to different conditions and declared that they can "live longer than most fishes without water. During droughts, as the waters subside and recede from the caves, they have the power, by a springing motion, of transporting themselves from one little puddle to another. They also have the power of partially burying themselves and living in the mud and among the moist grass-roots, after the other small fishes associated with them are all dead for the want of water. In these situations vast numbers of them are devoured by birds, muskrats, and foxes."

This power of adaptation enables them to find a winter-home with the least waste of energy and loss of life, and to hibernate in the mud. The mud was found by Abbott in midwinter to be of "the consistence of cheese, though, of course, it was less firm when the fish entered it, weeks before." As far as he was "able to determine the fish had burrowed tail-foremost to a depth of from four to nine inches." In every instance "the tail was deeper in the mud than the head, the position varying from nearly horizontal to almost or quite perpendicular."

Abbott thought that when they "had gone into winter-quarters" in water from "three to five feet deep, the hibernating slumber was not as profound; and when they were placed in clear water, at a temperature of 40° Fahr., they almost immediately swam about, slowly at first, but with steadily increasing activity, and in from three to five minutes they were in full possession of all their locomotive powers and assumed the statue-like position common to them in summer."

Soon after the returning warmth of spring has liberated the fishes from their long confinement, or even before spring itself has arrived, they manifest renewed vigor and sexual excitement. They had previously segregated themselves, in large part at least, according to sex—males in one lot, females in another. Abbott found in the middle of one February that, "the weather being mild and spring-like and frogs singing at mid-day," they were in muddy ditches; a week later there were few of the fishes in the ditches, "but a vast number of females, heavy with masses of ova," had invaded "the swift, clear waters of the hill-side brooks," and they continued to ascend in spite of succeeding storms and cold—especially a heavy snow-storm. "Of the specimens taken from the rivulets at this time, none were males." "Certainly the females precede the male fish to the spawning-grounds." Abbott was convinced that "while these fish at the commencement of winter seek shelter from the cold by burrowing deeply in the mud, at the approach of spring they revive synchronously with the maturing of the ova of the female and the milt of the male, and, having thus recovered their wonted activity (during February and March) no severity of the weather appears to deter them from seeking out exceptionally cold waters for their spawning-grounds. This was shown by the snow-storm referred to, after which the female minnows were still found passing up the brooks, forcing their way up miniature cascades with all the agility of salmon, leaping from eddy to eddy, seeking out the most distant points from their muddy summer haunts; and here, where but little water flowed, and with the long grass and twigs projecting from it thickly coated with crystal ice and glistening frost," Abbott "found the plainly colored mud-minnows lying half-hidden among the pebbles and sandy ridges of the brook's bed."

But if Umbras ascend running streams as far as they can go to spawn, it is not because they cannot do otherwise. The fact that they abound in numberless ponds shut off from all running water is sufficient evidence that they can reproduce in still water. They are said to have also spawned in confinement, as has been claimed by Seeley in case of the European species.



In like localities the eggs of the *Umbra* were found by Ryder (1886), "laid singly upon aquatic plants to which they adhere for a time by means of a thin coating of adhesive matter which invests them." The eggs are about a millimeter and a half ('1.6 mm.') in diameter. A peculiarity of the fertilized egg is that, at the time of the formation of the blastodisk, "the vitellus displays a most active amœboid activity of its substance," and Ryder remarked that he knew "of no teleostean egg" in which "such amœboid movements of the vitellus are so pronounced and rapid." On or about "the sixth day" after oviposition, "the young mud-minnow leaves the egg," and "three days after hatching the air-bladder becomes apparent as a fusiform vesicle behind the pectorals and above the foregut, when the young fish is viewed as a transparent object." Then "pigment is rapidly developed upon the upper and lateral aspects of the body, and by the sixteenth day the larvæ have become pretty dark in color, when observed from above."

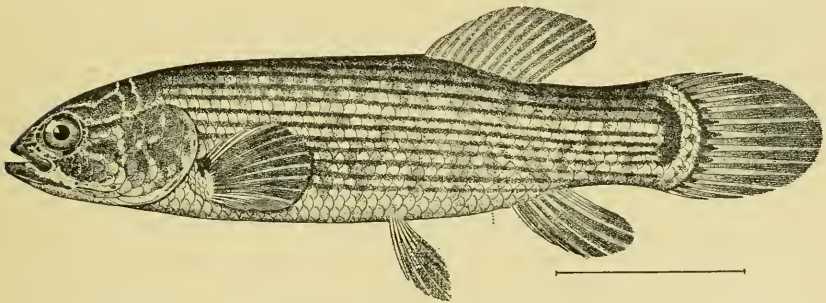


FIG. 38.—Western Umbra (*Umbra limi*). After Jordan and Evermann.

The mud-minnow is an excellent fish for aquaria, as it will live under conditions which other fishes cannot stand. Some kept in a small jar lived for months without change of water save for that supplied only sufficiently to compensate for what was lost by evaporation. The only plants for keeping the water clear were some Oscillariaceous confervæ. The fishes would ascend from time to time to the surface and reject bubbles of air (carbonic acid gas) and take in with a gulping action fresh air. Some were kept for about a year by the present writer in a large glass jar; during an unusually cold period the water froze solid and the jar was broken. The lump of ice was allowed to melt gradually and all the fishes revived and swam about as lively as ever in the new receptacle furnished them. A sudden transfer of frozen fish to "temperate" or summer water was found to be injurious or even fatal.

The European *Umbra* could not be induced by Heckel and Kner to spawn in captivity, and a female which was kept for a year in a small garden basin perished because, although filled to distension with eggs as large as millet seeds, it could not relieve itself of them. When one of a company dies, the rest soon follow it.

The Umbras have no economic value and are even considered by many to be poisonous. For a time at least in bygone years they were frequently to be seen in the markets of Vienna generally mixed up with a loach (*Misgurnus fossilis*), but not sold independently. Of course they were not sought for or caught intentionally, but simply scooped up with other contents of the net. Fishermen indeed, it is said, have a superstitious belief that it brings bad luck to catch Umbras.

#### IV

Three species of the genus and family are known, distributed and distinguished as follows:

UMBRA UMBRA (*Umbra krameri*): the European Umbra.—South-west Europe, especially Hungary.

The body is light brownish and has lighter longitudinal lines on the rows of scales including and below the lateral line as well as more or less irregular darker spots scattered over the surface. There is no precaudal bar but a trace of one on the caudal fin near its base. An indistinct darker area exists on the scapular arch behind the branchial chamber. The head has a suborbital spot sometimes developed as a transverse bar. The fins are immaculate.

UMBRA LIMI: the Western Umbra or Mud Minnow.—Basins of the Great Lakes and Ohio and Illinois rivers, in weedy streams, ditches, and pools.

The body is very dark brown relieved by about twelve to fifteen vertical narrow lighter bands, some of which often coalesce; the last is bounded by a blackish precaudal bar and there is a lighter bar on the caudal fin near its base. A silvery bar is on the scapular region behind the branchial chamber. The head has a frenal band extending from snout on to operculum, but skipping eyes. The fins are immaculate.

UMBRA PYGMÆA: the Eastern Umbra or Mud Minnow.—Atlantic slope from Connecticut southward to South Carolina in lowland streams, ponds, and pools.

The body is light brown and has about as many longitudinal light lines as rows of scales, that along the lateral line being most vivid. There is a very distinct blackish precaudal bar or vertical spot and a fainter bar at the base of the fin. A silvery band is developed

behind the branchial chamber. The head has a bridle-like band extending from the snout on to the operculum, skipping the eye. The fins are immaculate.

There are slight structural differences in proportions of body, head, and fins between the several species, but they are so unimportant that they need not be specified here. The U. S. National Museum has numerous specimens of all the species. To Dr. Hugh M. Smith, Deputy Commissioner of Fisheries, the writer is also indebted for the opportunity to observe living individuals of the Eastern Umbra which were obtained by digging or dipping deep into the mud at the bottom of a run near the city of Washington.

It is really remarkable that, with such adaptability and such power of endurance as they possess, the range of the genus should now be so restricted. Restricted it undoubtedly is, for the European and American species must be the relics of a once widely dispersed group.

## V

Here have been given the essentials of what is known respecting the habits and economy of the Umbrids. Several of the statements, however, require verification, especially such as refer to the segregation of the males from the females and the ascent of both upstream. The entire nature of the oviposition, also, should be especially investigated; and there are the history of the development of the young, the growth from season to season, and the age at which maturity is attained to be inquired into. The present sketch is, therefore, only a preliminary from which to start.

## A NEW OCCURRENCE OF UNAKITE—A PRELIMINARY PAPER

By W. C. PHALEN

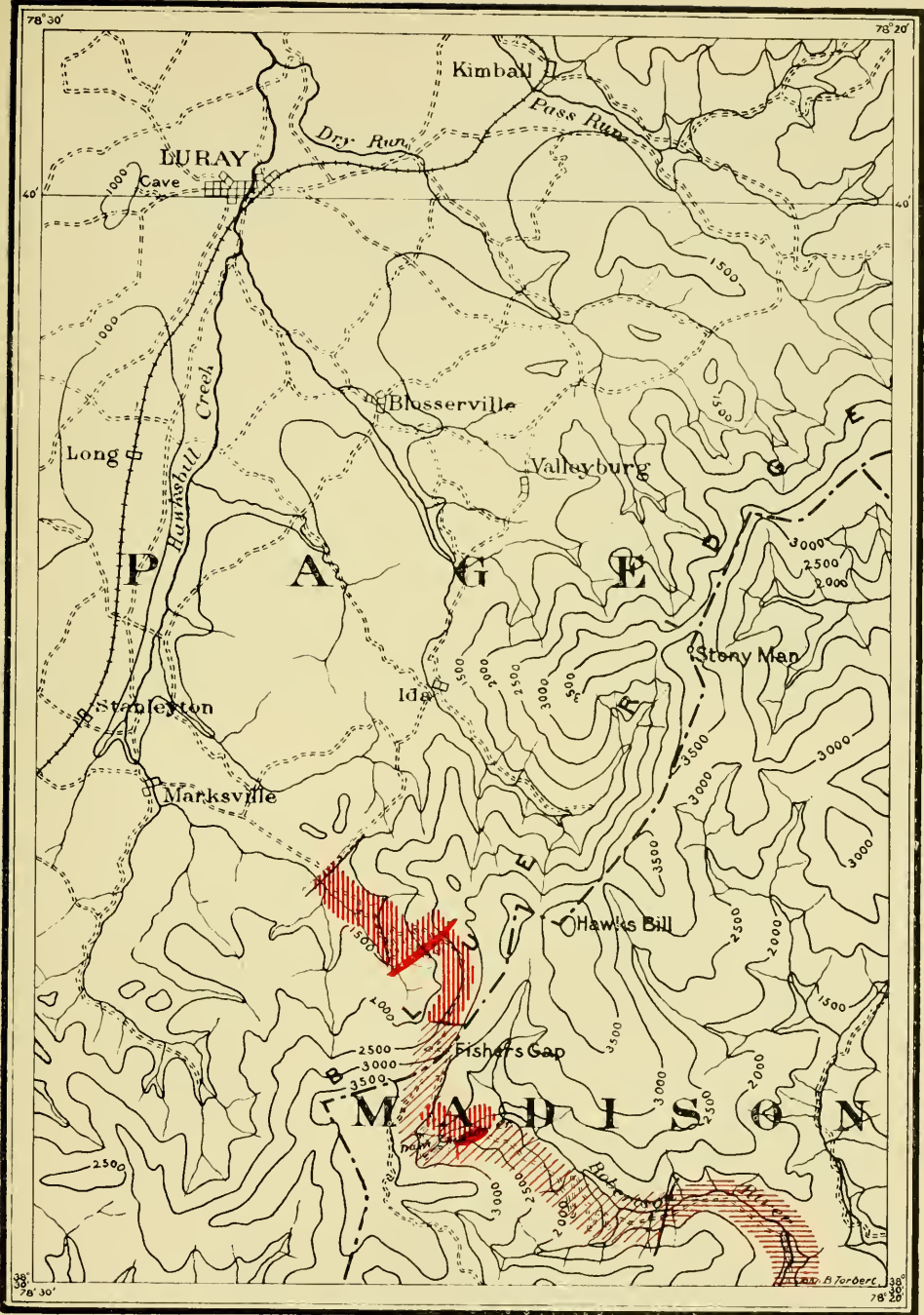
### INTRODUCTION

In 1884, Prof. W. M. Fontaine, of the University of Virginia, sent to the U. S. National Museum a specimen of igneous rock of exceptional interest, occurring at Milams Gap (see Fishers Gap, pl. LXIX) at the summit of the Blue Ridge, seven miles south of Luray, Va. The rock was entered and placed among the granites under the caption unakite. In the spring of 1903, in response to a letter from Dr. G. P. Merrill, head curator of the Department of Geology, U. S. National Museum, Professor Fontaine sent another consignment of specimens with the associated country rock and at the same time a detailed description of where the unakite might be found.

Later in the spring the writer spent a day at the locality in the company of Dr. Merrill, and in the fall he spent three days alone in the region, mapping the rocks and making collections as extensive as the limited time allowed. The following brief descriptions are the result of the two excursions.

Before describing the rocks, attention should be called to plate LXIX. It will be noticed that the boundaries of the rock masses on either side of the road, leading to and from the summit, have been left open. This was rendered necessary as it was not possible to ascertain their true extent in the limited time available; it is hoped, however, that this work may soon be accomplished. Certainly from a petrographical point of view the country is one deserving of further and detailed study.

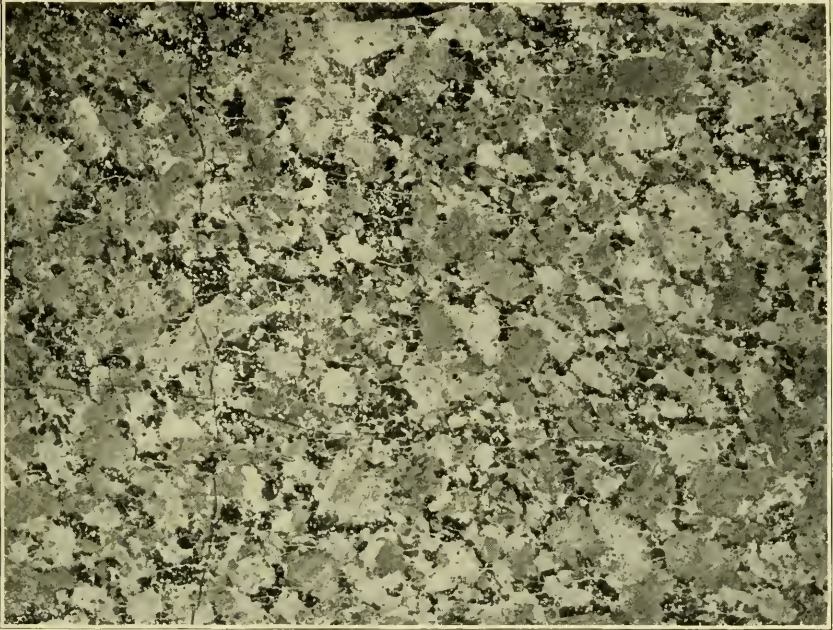
So far as the writer is aware, this Virginia locality is the second in America where unakite occurs in appreciable quantity, the first being the Unaka mountains between North Carolina and Tennessee, whence the rock derives its name. It is highly probable, however, that the rock is not nearly so limited in distribution as this statement would seem to imply. At Marblehead Neck, Mass., for example, some rather imperfect specimens were obtained a few years ago, the unakite occurring as a dike in diorite (see pl. LXX, *b*). Here the epidotic material has undoubtedly resulted from alteration of the colored



Hypersthene Akerite      Unakite      Olivine Basalt      Granite

MAP SHOWING DISTRIBUTION OF UNAKITE AND ASSOCIATED ROCKS NEAR LURAY, VIRGINIA.  
 (Base map from the Luray sheet of the U. S. Geological Survey.)





*a.* Polished section of unakite. Natural size. (Milams Gap, Va.)



*b.* Dike of unakite in diorite. Natural size. (Marblehead Neck, Mass.)





components of the adjacent rock and is secondary. Such a peculiar combination of quartz, orthoclase, and epidote should not be uncommon in regions of dynamic or static metamorphism where granites or other feldspathic rocks occur, containing the colored micas, pyroxenes, amphiboles, etc.

The term unakite was applied originally in 1874 by F. H. Bradley,<sup>1</sup> who, in the reference cited below, says:

“This name unakite is proposed for a member of the granitic series from the Great Smoky Mts., a portion of the Unaka range of the Blue Ridge, which range forms the boundary between North Carolina and Tennessee.

“The specimens thus far seen are from the slopes of the peaks, known as ‘The Bluff,’ ‘Walnut Mt.,’ and ‘Max’s Patch’ in Cocke Co., Tenn., and Madison Co., N. C. The rock is said to occur also in Yancey Co., N. C., but in a comparatively inaccessible region.

“The character relied on for the separation of the species is the constant replacement of the mica of common granite or the hornblende of syenite by epidote. The amount of this ingredient present is quite variable, in some cases even exceeding one half of the whole mass. The feldspar present is orthoclase of various shades of pink, forming from one fourth to one third of the whole. The quartz is mainly white, but occasionally smoky; its isolated portions form but a small part, say one fourth of the mass; it is veined in structure, but this is probably not a constant character. Small grains of magnetite are scattered through the rock, but not so thickly as in many granites. No other ingredients have as yet been detected. Mr. G. W. Hawes has determined the specific gravity at 2.79. The rock is very compact and takes a high polish and will doubtless prove a valuable material for ornamental architecture.

“The deep weathering of all the rocks of the southern Appalachians has caused the covering of these slopes with deep beds of debris, which conceal most of the outcrops and the dimensions of the bodies of unakite are therefore, as yet, unknown.”

A perusal of the literature since Bradley’s brief description in 1874 reveals nothing more than mere allusions to the name and occurrences of the rock.<sup>2</sup> It is not mentioned in the latest petrographical lexicon of Löwinsson-Lessing, and, so far as the writer is aware, the only reference to the Milams Gap locality is by Merrill.<sup>3</sup>

Mr. F. B. Laney, who spent the last season in a survey of the building stones of North Carolina, informs me that the unakite of

<sup>1</sup> *Am. Jour. Science*, 3d series, vii, 1874, pp. 519-520.

<sup>2</sup> Dana, *Manual of Geology*, 4th ed., p. 85. Merrill, *Rocks, Rock-weathering and Soils*, 1897, p. 68. E. H. Williams, *Manual of Lithology*, N. Y., 1895, p. 128. Williams also calls attention to the occurrence of unakite in the Fichtelgebirge, Schwarzwald, and the Pyrenees.

<sup>3</sup> *Stones for Building and Decoration*, 1903, p. 86.

that state occurs as irregularly segregated patches in a foliated or gneissoid epidotic granite, a very different rock, at least macroscopically, from the country rock at Milams Gap, and that, so far as he is aware, it is confined to Madison county, North Carolina, and Cocke and Sevier counties, Tennessee.

#### GEOLOGY AND PETROGRAPHY

The Blue Ridge at Milams Gap, Virginia, is a single range, composed entirely of igneous rocks. Proceeding from Stanley, on the Norfolk and Western Railroad, by the public road which runs south-eastward through the village of Marksville, the transported material of Hawksbill creek is finally left behind in large measure and the igneous rock in place is first encountered at an elevation of 1,260 feet.<sup>1</sup>

The rock, the hypersthene-akerite of the succeeding pages, continues in almost unbroken continuity to the olivine-basalt, mapped as beginning at an elevation of 2,600 feet. The first fragments of unakite were observed at 1,640 feet, but are probably not in place. The first distinct mass of the material occurs at from 80 to 125 feet below the sharp turn in the road represented on the 2,000-foot contour. Much epidosite is associated with it. No sharp lines of demarcation between it and the akerite can be distinguished, and the mass cannot be more than 10 feet wide. The mass, which is probably a continuation of that noted higher up on the road, trends north, 75° to 80° east. It is represented on the map as being rather regular, or as a dike. The masses seen, however, are too irregular to be classed as true dikes; they may more properly be termed irregular patches. The main mass of unakite occurs on the eastern slope of the ridge, where it is associated with akerite, a large mass of which is found in the basalt on this side of the ridge. Most of the material here is in the form of débris.

It is to this spot that collectors should go for the material in quantity, "the best specimens being obtained along a foot-path that cuts off the first curve in the road in descending on the east side."<sup>2</sup> I may add that excellent specimens may also be obtained in the formerly cultivated fields lying on the right as one continues down the road, just beyond the head of the path referred to.

In order to make the discussion of the origin of the unakite more intelligible, the results of the microscopic examination of the country rock will first be presented.

<sup>1</sup> All elevations were determined by means of an aneroid.

<sup>2</sup> Fontaine's letter.

*Hypersthene-akerite*<sup>1</sup>

Akerite, the country rock of the unakite, is a very coarsely grained, dark grayish green aggregate of feldspars and black pyroxenes with here and there an occasional speck of limpid quartz. The greasy appearance of some of the constituents is strongly suggestive of the mineral nephelite, though the chemical and microscopic analyses show that none of this mineral can be present. The albite twinning of the plagioclase feldspar is plainly seen on many of the fresh fractures and an occasional Carlsbad twin is also evident.

In thin section the following minerals were noticed: Orthoclase, plagioclase, orthorhombic and monoclinic pyroxene, quartz, microcline, iron ore, apatite, and zircon, with the decomposition or alteration products, epidote, chlorite, and sericite. Hornblende is absent in most of the slides studied. In a light-colored segregation situated near the upper boundary of the akerite (a single instance, it may be observed), large masses of hornblende crystals were noticed. The microscopic features of the hornblende will be alluded to in the subsequent descriptions. The accompanying drawing (fig. 39) represents the crystallization of the hornblende in the light-colored segregation of the country rock.

The minerals are arranged in a hypautomorphic mosaic, which is strikingly clear and beautiful when fresh. By far the most abundant

mineral is feldspar, which shows evidences of strain in the bent albite lamellæ and frequency of wavy extinction. It is often asso-



FIG. 39.—Hornblende in lighter phase of akerite. (Scale 1" = 1'.)

<sup>1</sup> Classified as harzose according to the quantitative scheme of Cross, Iddings, Pirsson, and Washington. For a revision of the calculation of the analyses according to the quantitative scheme, and for examining the proof, I am indebted to Dr. H. S. Washington. Dr. Washington was also kind enough to point out a discrepancy in a former paper by me on "The Rocks of Nugsuaks Peninsula, Greenland" (*Smithsonian Miscellaneous Collections*, XLV, p. 183), in which, in the calculation of the rangs, percentages instead of molecular proportions were employed. This necessitates changing omeose (p. 209) and dellense (p. 212) to positions in the next subrangs in each instance. They are, therefore, liparose and toscanose, respectively.

ciated with quartz, producing the micrographic structure. While much of the feldspar shows albite twinning, a larger portion shows no such phenomenon, and it is evident from the frequency of the parallel extinctions that much orthoclase must be present. It does not appear to be so susceptible to kaolinization as the more basic plagioclase. The latter is generally twinned according to the albite law, and its symmetrical extinctions, ranging as high as  $18.7^\circ$ , indicate a feldspar intermediate between andesine and acid labradorite, more nearly the former than the latter. Perthitic intergrowths were noticed; also a curious instance of secondary feldspar twinned according to the albite law, enclosed in a feldspar of less refractive power. This is not true micropertthite, and its development is undoubtedly the result of pressure, the enclosing feldspars showing the effect of strain in their wavy extinctions.

The more basic feldspars, it has been noted, are the more kaolinized. They contain areas of brownish, cloud-like masses, non-reactive between crossed nicols. Other inclusions consist of little tufts or fibers, which polarize brightly; these are often arranged along cracks or cleavage planes and are to be referred to the mineral sericite. Fluid inclusions are present, together with minerals of earlier crystallization, iron oxide, apatite, and zircon.

The colored constituents include the light-green monoclinic pyroxene, which, from the low extinctions and presence of characteristic partings, is to be referred to the mineral diallage. This monoclinic variety is generally associated with hypersthene, the two minerals being frequently intergrown. Many inclusions of iron oxide, both primary and secondary, are present, the hypersthene being apparently very susceptible to change. The secondary iron oxide is often present in masses simulating skeleton forms, which, coalescing, form larger masses often seamed with dark green chloritic matter. Epidote often occurs along the fissures or cleavage planes.

In but few sections studied was amphibole observed. It occurs in rather large patches (one inch and less) in a light-colored segregation of the country rock at an elevation of about 2,400 feet. It is the usual brown variety, strongly pleochroic, as follows: *C*, brown; *A*, brownish yellow; and *B*, chestnut brown with absorption scheme  $B \cong C > A$ . This is rather unusual, but the difference between the absorption parallel to *B* and *C* is very slight.

The presence of primary quartz is of interest in this relatively basic rock. It occurs in large isolated masses and is also intergrown with the feldspar. Iron oxides (both hydrous and anhydrous),

apatite, and zircon, together with the alteration products, chlorite, epidote, and sericite, complete the list of minerals present.

This rock has been referred to the hypersthene-akerites, a type named and described by Brögger<sup>1</sup> as being essentially quartzose augite-syenites, the feldspars comprising both orthoclase and plagioclase. For convenience of comparison in the subsequent discussion, a table of analyses is inserted.

	Hypersthene-akerite, Williams Gap, Va.	Hypersthene akerite, Barnekjern See, Veta- kollen, Norway. Kje- mit analyst. Brögger, <i>Zeit. f. Cryst.</i> , 1890, xvi, 50.	Hypersthene-andesite, Richmond Mt., Eureka Dist., Nevada; T. M. Drown analyst. Id- dings, Monograph xx, U. S. G. S., p. 264.	Hornblende-syenite, Plauen schz Grund, Dresden. Zirkel, <i>Ann. der Chemie u. Physik</i> , cxxxiii, p. 622.	Augite-syenite, E. W. Morley, analyst. H. P. Cushing, <i>Bull. G. S. A.</i> , x, 183.
SiO <sub>2</sub>	60.52	59.92	61.58	59.83	63.45
Al <sub>2</sub> O <sub>3</sub>	16.99 <sup>(2)</sup>	16.07	16.34	16.85	18.31
Fe <sub>2</sub> O <sub>3</sub>	.60	} 8.76	—	—	.42
FeO	6.53		6.42	7.01	3.56
MgO	1.59	2.07	2.85	2.61	.35
CaO	4.58	4.56	5.13	4.43	2.93
Na <sub>2</sub> O	2.83	3.02	2.69	2.44	5.06
K <sub>2</sub> O	3.91	2.82	3.65	6.57	5.15
H <sub>2</sub> O	.88	.67	.64	1.29	.30
P <sub>2</sub> O <sub>5</sub>	.74	—	.28	—	Tr.
MnO	.25	—	—	—	Trace.
BaO	—	—	—	—	0.13
TiO <sub>2</sub>	n. d.	—	.68	Trace.	.07
ZrO <sub>2</sub>	Tr.	—	—	—	—
Cr <sub>2</sub> O <sub>3</sub>	Tr.	—	—	—	—
	99.42	97.89	100.26	101.03	99.73

It will be seen that the resemblance between analysis No. 1 and that of Brögger's green, fine-grained akerite from Barnekjern is very close, and though of little import, it is of interest that the rocks agree very closely as to mineralogical content, biotite being the only component lacking in the Virginia rock to make the resemblance perfect. More specifically the name hypersthene-akerite should be applied, instead of simply akerite, and this name is here adopted. The rock is also similar to Zirkel's Plauen'sche Grund hornblende-syenite and Iddings' hypersthene-andesite from Richmond Mt., Nevada, to draw an illustration from a less perfectly crystallized magma. The types described by Cushing<sup>3</sup> (analysis 5), the Diana gabbro of Smythe,<sup>4</sup> and the Gloucester, Mass., akerite of Washington<sup>5</sup> are all

<sup>1</sup> *Zeitschrift für Crystallographie* xvi, p. 51.

<sup>2</sup> Including TiO<sub>2</sub>.

<sup>3</sup> *Bull. Geol. Soc. Am.*, x, 183.

<sup>4</sup> *Ibid.*, vi, 271-274.

<sup>5</sup> *Jour. Geol.*, vi, 796-798.

too rich in the more acid feldspars to admit of close comparison. All, however, show general relationship to the Virginia type and it is probable that more alkalic phases of the latter rock exist.

*Unakite*<sup>1</sup> (Cat. No. 75,518)

This rock is an irregular crystallization of old-rose feldspar and green epidote, the latter generally occupying the spaces between the feldspar. The peculiar green of the epidote, together with the old-rose hue of the feldspar, make a striking and beautiful combination, and were the rock sufficiently abundant to justify exploitation, its quarrying must certainly prove a profitable venture. As the case now stands, the working of the deposit is out of the question for the reason that there is not enough of it. Its use for outside decoration cannot be considered, owing to the relative ease with which the rose-colored feldspar bleaches to a white product.

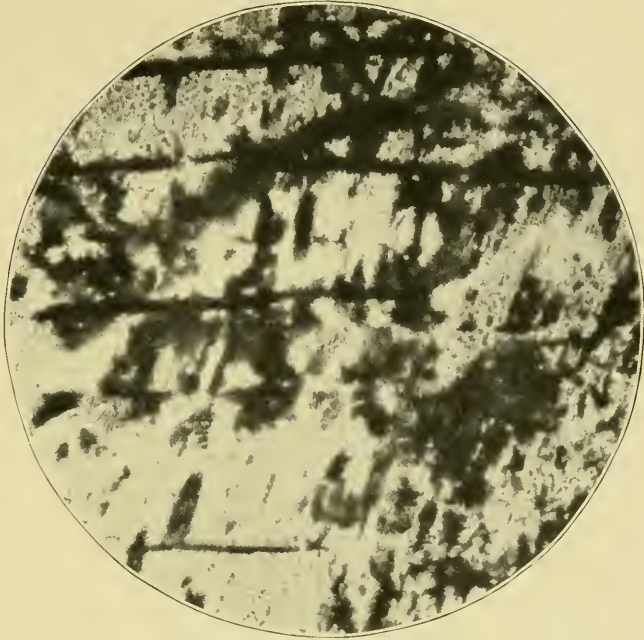
It has been noted that the crystallization of the feldspar, quartz, and epidote is very irregular. In some specimens gathered from the type locality on the eastern slope of the ridge, the red feldspar constitutes fully three-fourths of the mass, and from this ultra-feldspathic phase, all phases through to the quartz-epidote (epidosite) combination may be seen.

Rarely an automorphic outline of a feldspar may be seen with a slightly resorbed margin. The largest phenocryst noted was 2.5 cm. The feldspar is specked with epidote and quartz, the former occupying the fissures and cleavage cracks. Where the epidote forms cloud-like masses, the feldspar appears to have been bleached.

Quartz is distributed in the spaces between the other minerals, also in the body of the feldspar and epidote. It is generally clear, perhaps inclined to the smoky type. It presents no unusual features, and with mention of an occasional piece of iron oxide, the list of macroscopic constituents ends.

In thin section epidote, feldspar, quartz, iron oxides, zircon, and apatite were seen. Epidote occurs in large granular aggregates. Frequently such masses have curved boundaries. It also appears as minute isolated dots in the mass of the feldspar and as stringers along the cleavage planes of this mineral. This occurrence is well represented in plate LXXI, *a*. The specks of epidote representing

<sup>1</sup> Although the secondary nature of this rock excludes it from proper classification according to the quantitative system of Cross, Iddings, Pirsson, and Washington, and although it is uncertain whether the original magmatic characters are retained or not, it may be mentioned that a magma of this composition would fall under the head of sagamose.



*a.* Unakite showing replacement of feldspar by epidote between crossed nicols ( $\times 53$ ).



*b.* Microstructure of hypersthene-akerite showing curved allite lamellae between crossed nicols ( $\times 53$ ).





replaced feldspar, in addition to their occurrence in the body of this mineral, form a fringe about the massive feldspar, and thus the gradual replacement of this mineral may be plainly seen.

The epidote is usually of a transparent yellowish green, but occasionally becomes dark green and opaque in the vicinity of the iron oxide, due perhaps to chloritic matter or to a larger content of iron oxide, most probably the former. The iron oxides show fractures filled with the same green pigment mentioned above; I judge them from this fact to be secondary and to have resulted from the same processes which have given rise to the green pigment. Some of the epidote is nearly colorless; other portions are striped by a darker variety along the cleavage cracks. These cleavages, when present, are very poorly developed, as is to be expected in secondary epidote, and for the same reason this origin interferes with the normal coloring. Hence vibrations may vary in different parts of the rock, but those noted are shades of yellowish green with absorption  $B > C > A$ .

The feldspar seems to be all orthoclase. It is almost perfectly clear in part, but when epidotization has begun, it is translucent. It is not colored in thin section, and the old-rose color noted in hand specimens is to be explained by microscopic inclusions of flakes of brown iron oxide, occurring in cloud-like masses more or less concentrated along the cleavage cracks.

The remaining constituents are quartz, brown and black iron ore, brown zircons, and apatites.

For convenience in comparison the analysis of unakite is given with that of hypersthene-akerite.

	Unakite, Milams Gap. Phalen, analyst.	Hypersthene-akerite, Milams Gap. Phalen, analyst.
SiO <sub>2</sub>	58.32	60.52
Al <sub>2</sub> O <sub>3</sub> (¹)	15.77	16.99
Fe <sub>2</sub> O <sub>3</sub>	6.56	.60
FeO	.89	6.53
MgO	.09	1.59
CaO	11.68	4.58
Na <sub>2</sub> O	.32	2.83
K <sub>2</sub> O	4.01	3.91
H <sub>2</sub> O	1.73	.88
P <sub>2</sub> O <sub>5</sub>	.48	.74
MnO	.13	.25
Cr <sub>2</sub> O <sub>3</sub>	—	trace.
ZrO <sub>2</sub>	trace.	trace.
	99.98	99.42

¹ Including TiO<sub>2</sub>.

*Origin of Unakite*

The two rocks have originated from the same magma, and the constituents necessary to produce the epidote are present in the hypersthene-akerite. These are the pyroxenes and plagioclase. In some sections, as already noted, under hypersthene-akerite, hornblende is present. Its very limited occurrence, however, precludes the possibility of its having been the chief source of the iron of the epidote. It is a well-known fact that epidote is a common mineral in regions which have undergone dynamic metamorphism,<sup>1</sup> and such influence may have had its effect in the present instance, for the wavy extinction and bent albite lamellæ (pl. LXXI, *b*) indicate that the region has been subjected to some stress. The relatively large content of water in the akerite is suggestive. But the chief cause of epidotization is perhaps due to the action of percolating meteoric waters (hydrometamorphism). The change of the pyroxenes to epidote may be seen in many of the sections studied. It begins along the cleavage cracks and on the edges of the minerals, gradually replacing them, thence extending to the plagioclase and ultimately replacing this mineral and orthoclase (pl. LXXI, *a*). It is accompanied by a separation of iron oxide in skeleton forms which gradually coalesce, producing the massive fractured forms noted under unakite. It was thought that this fractured phase of the iron oxide might be due to a partial removal of its mass to form epidote, but the resistance of this mineral to alteration precludes this possibility. The presence of much potash does not militate against this origin by percolating waters, for the potash varieties of feldspar, as is well known, are far more resistant than the soda-lime varieties.<sup>2</sup>

Magnesium is also frequently removed in greater proportion than lime.<sup>3</sup> In this connection, the presence even of small amounts of soda and magnesia is suggestive, for it indicates the former presence of those minerals involved in the formation of the epidote.

*Epidosite*

The term epidosite has been used in the previous pages for a quartz-epidote combination—the non-feldspathic phase of the una-

<sup>1</sup> Lindgren, *Metasomatic Processes in Fissure Veins*, *Trans. A. I. M. E.*, xxx, 611.

<sup>2</sup> "Among the feldspars, the potash varieties are, as a rule, more refractory than the soda-lime or plagioclase varieties. This is shown not merely by our own observations, but by those of others as well. Roth shows from analyses of fresh and weathered phonolite, nepheline-basalt, and dolerites that the loss of soda is almost invariably greater than that of potash."—Merrill, *Rocks, Rock-weathering and Soil*, p. 236.

<sup>3</sup> *Ibid.*, p. 239.

kite—as it proves when examined macroscopically. Though feldspar is not readily apparent to the naked eye, it may be seen in thin sections largely replaced by epidote. A small amount of untwinned plagioclase is also present. The remaining minerals are zircon, hydrous and anhydrous iron ore, and apatite. The derivation of this rather rare rock from the unakite is very apparent; it represents an advanced stage of epidotization.

#### *Olivine-basalt*

The mass of the rock constituting the ridge in this vicinity, and to whose resistance the ridge owes its superior height, is a dull green aphanatic mass whose constituents, excepting an occasional speck of epidote and partially altered olivine, cannot be determined with the naked eye. This olivine-basalt is younger than the granite lying to the east, and may be later than the boss of akerite, though future work only will settle this point definitely. Its intrusion in the granite has resulted in profound metamorphism of the latter rock in the border zones, the ordinarily massive rock having become decidedly gneissoid. Large fragments of basalt, generally epidotized, occur near the contact, which appear as though they had solidified, had been wrenched from the wall, and had then fallen back into the magma in its upward motion. Columnar joining in the basalt is well developed north of the Gap at Franklin Cliff.

The olivine of the basalt occurs as phenocrysts, sometimes 3 or 4 mm. in diameter, and generally presents a thoroughly corroded periphery, surrounding a tolerably fresh nucleus. At times even this has disappeared, leaving a brownish red mass to mark its former position. The results of the microscopic examination indicate almost complete alteration, and the determinable constituents are few in number, consisting chiefly of feldspar, pyroxene, olivine, magnetite, with chlorite, epidote, and iron ore. The feldspar and pyroxene constitute the mass of the rock. Imbedded here and there in the mass occurs the olivine, partially filled with a network of brown decomposition products, mostly iron oxide. Besides this ochereous material, there are amorphous, cloud-like masses scattered about in abundance, generally associated with the ferruginous constituents and evidently produced as a result of their decomposition. There are present in addition, epidote and chlorite, the latter in scales or shreds polarizing with dull-gray or bluish tints. In some green phases, epidote constitutes the bulk of the rock.

## SUMMARY

1. Four rocks are described, namely, hypersthene-akerite, unakite, epidosite, and altered olivine-basalt. The first two mentioned are of more than ordinary interest, owing to their rather restricted distribution.

2. The term unakite has been applied to a rock whose mineral components would place it among the granites, with epidote as an essential constituent, but whose analysis is relatively basic for this type of rock. This name was applied by Bradley in 1874 to a similar rock from the Unaka mountains, North Carolina, and so far as the writer is aware, its occurrence at other places has not been referred to.

3. The name hypersthene-akerite has been applied to a hypersthene-quartz-diallage-syenite in the sense originally proposed by Brögger.

4. The unakite has originated from the akerite by the process of hydrometamorphism, aided and perhaps induced by dynamic disturbances.

5. The relative ages of the akerite and basalt are not given, since they could not be determined with certainty in the limited time available for field work. It is hoped that in the near future opportunity for more extended study will be presented. The basalt is younger than the granite on the eastern slope.





SKELETON OF TRACHODON IN THE U. S. NATIONAL MUSEUM. (Mounted by Alban Stewart.)

## THE DINOSAUR TRACHODON ANNECTENS

By F. A. LUCAS

The skeleton of *Trachodon*, or *Claosaurus*, recently placed on exhibition in the U. S. National Museum, is an unusually perfect example of that group of extinct reptiles, the dinosaurs. It was included in the Marsh collection and was one of two nearly complete skeletons obtained by Mr. J. B. Hatcher some years ago on Lance creek, Wyoming. The completeness of the specimen is due to the fact that the animal was either engulfed in quicksand, and so came to his end, or that by some favorable accident, such as a cloudburst or a freshet, the body was otherwise covered with sand immediately after death, and before decomposition had set in. Whatever may have happened, the result was that the bones remained in place, the ribs being attached to their respective vertebræ and the great thigh bones remaining in their sockets, the legs even having the position they would take in walking. This is shown in pl. LXXII, for in mounting the skeleton the ends of the thigh bones were left as found. Some examples of *Trachodon* have been obtained in which the impression of the skin was preserved in the surrounding rock, and from these it is known that this animal was covered with small, irregularly six-sided, horny plates, somewhat like those covering portions of the bodies of crocodiles. Unfortunately the wearing away of the rock in which the present specimen was contained had exposed some of the bones, and portions of them had been damaged and the front of the skull weathered away before its discovery in the summer of 1891. The rock containing the bones was then taken up in sections and shipped to Yale University where a large portion of the matrix was removed in order that the bones might be studied. This revealed the presence of long, slender bones, or ossified tendons, that had been embedded in the muscles overlying the backbone in the region of the back and upper part of the tail, and still situated as they were in life. These tendons are not shown in the specimen as mounted, because in order to display the vertebræ it was necessary to remove the tendons and the underlying rock; they are, however, present on the right side which is buried in the background. The object of these tendons is to afford support to the muscles of the back and tail and to strengthen

these regions of the body. Similar ossified tendons are found in many diving birds, such as auks and loons, the object being to brace the body against the strain it is called upon to undergo when a fish is caught and is carried in the beak. In the case of *Trachodon* the strain was due to the weight of the tail, which was, as we shall see, held clear of the ground in walking.

The final preparation of the skeleton, its mounting, and the restoration of the missing or damaged parts was most skilfully performed by Mr. Alban Stewart, of the U. S. National Museum, who devoted to it many months of patient work.

*Trachodon* is a typical example of that group of dinosaurs called Predentata because the front of the lower jaw is formed by a bone preceding the tooth-bearing portion, and therefore termed the pre-dentary bone. This was probably encased in horn, like the beak of

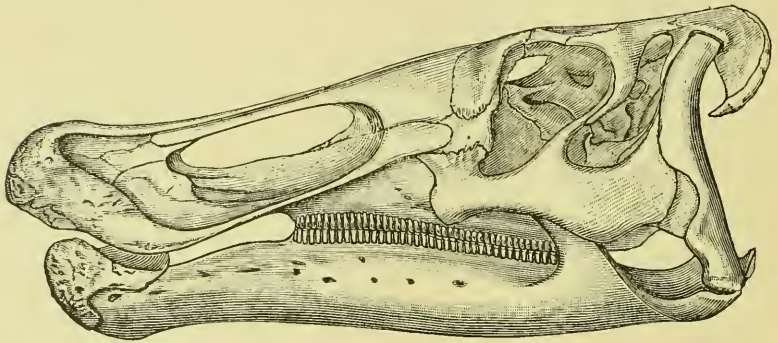


FIG. 40.—Skull of *Trachodon*, showing the pre-dentary bone.

a turtle, and served for nipping off the branches or herbage on which these animals fed. As the members of the Predentata had but three well-developed toes on the hind feet, and often no more, so that their feet resembled those of birds, the group has also received the name of Ornithopoda, or bird-footed. The animals of this division were all herbivorous and were probably preyed upon by their carnivorous relatives. The particular subdivision, or family, of which *Trachodon* is a member is called the Iguanodontidæ (iguana-toothed), from the name *Iguanodon* bestowed by Mantell on the first species found in England, the name being given because the teeth were attached to the inner side of the jaw as in iguanas. In the case of *Trachodon* there were several series of teeth placed one above the other, the entire series moving slowly upward, new teeth forming at the base to supply the place of those worn away at the top. This arrangement greatly increased the number of teeth, there being over two







SKELETON OF TRACHODON (HADROSAURUS) AS RESTORED BY  
B. WATERHOUSE HAWKINS.

hundred on each side of the lower jaw, so closely packed together as to appear like a mosaic pavement.

The family of *Iguanodons* had an extensive geographical range, for their remains have been found in Austria, Belgium, and England; and in New Jersey, Colorado, Wyoming, Montana, and Alberta, in North America. The first hint of their presence in this country was the discovery of teeth in the Judith River region, Montana, in 1856; but not until a partial skeleton was found near Monmouth, New Jersey, was it fully realized that these teeth belonged to some relative of the European *Iguanodon*.

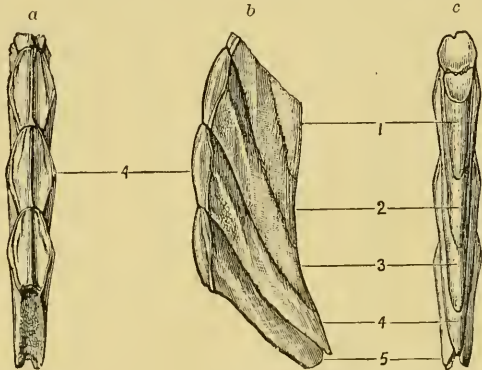


FIG. 41.—Series of five teeth of *Trachodon*, showing the new teeth at the bottom, and the old, worn teeth at the top. Somewhat reduced.

The New Jersey specimen was described by Doctor Leidy under the name *Hadrosaurus foulkii*, and the bones,

which were deposited in the Academy of Natural Sciences of Philadelphia, furnished the basis for a restoration of the skeleton by Mr. B. Waterhouse Hawkins. At this time the structure of the dinosaurs was not well known, and Mr. Hawkins, who was not a comparative anatomist, while recognizing the upright position of the animal, restored the missing parts from the skeleton of a modern iguana, the result being the skeleton shown in plate LXXIII. While this restoration was far from cor-

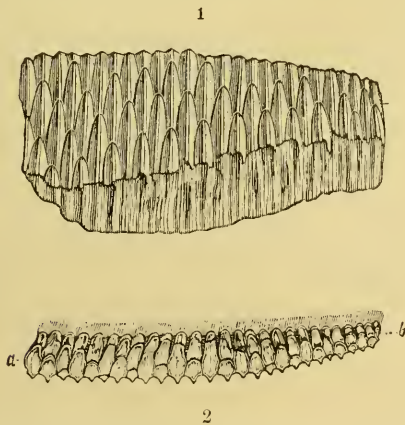


FIG. 42.—Group of *Trachodon* teeth (1) seen from the outer side and (2) from above. Much reduced.

rect, especially in regard to the skull, it was a decided improvement on that of *Iguanodon* shown at the Crystal Palace,

Sydenham, which represented this dinosaur as a sort of elephantine reptile walking on all fours. That *Trachodon* and his kindred walked erect and carried their tails clear of the ground is indicated by their structure, while much light is thrown on the subject by tracks made by various dinosaurs. At Hastings, England, is a series of thirty great bird-like tracks, ascribed to *Iguanodon*, and showing no imprint of fore-feet nor any furrow such as would have

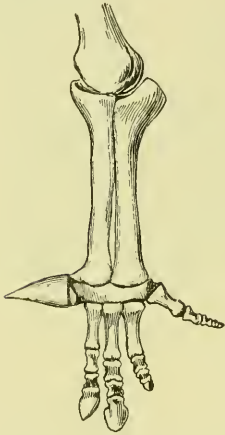


FIG. 43.—Fore-foot of *Iguanodon*.

been made by the dragging of a heavy tail. Just such furrows, associated with the prints of four feet, are present in some of the famous specimens from Connecticut valley, while they are absent when the impressions are three-toed, like those at Hastings.

The front foot of *Trachodon* had four toes, the innermost being movable, somewhat like a thumb, so that the foot could be used for grasping. The forefoot, however, was by no means so long and slender as might be inferred from a glance at the skeleton, since the longer bones were surrounded by flesh, the effect being that of a hand with an exceedingly long palm and short, stubby fingers. The forefoot of the related *Iguanodon* had a thumb like a short, stout spike, standing

out at right angles to the other digits (figure 43) and probably serving some useful purpose in gathering or handling food. When this spike was first found it was separated from the other bones of the hand, and was supposed to belong on the nose, after the fashion of the horn of the rhinoceros.

What may be called the companion to the skeleton in the U. S. National Museum, that mentioned near the beginning of this article, is on exhibition in the museum of Yale University, and was the first complete skeleton of a dinosaur to be mounted in the United States. The Yale specimen is slightly the larger of the two, measuring a trifle over 29 feet in total length, but had suffered more from the weather and so needed more restoration. The skeleton in the U. S. National Museum is 26 ft. 4 in. long; 11 ft. 6 in. high from the base to the top of the head, and 8 ft. 2 in. to the top of the hips; the skull is 3 ft. 5 in. long, the thigh bone 3 ft. 4 in., while the track would have been about 21 inches in length and breadth.

# CLASSIFICATION OF THE HARES AND THEIR ALLIES

By MARCUS WARD LYON, JR.

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## I. INTRODUCTION

The object of this paper is to give an account of the principal osteological features of the hares, rabbits, and pikas or duplicidentate rodents, the Duplicidentata, and to determine their family, generic, and subgeneric relationships.

The subject is treated in two ways. First, there is a discussion of each part of the skeleton and of the variations that are found in that part throughout the various groups of the existing Duplicidentata. Second, each of these groups is separately considered, and the characters of its skeleton described. The treatment of the osteology in these two ways is followed by three keys to the genera and subgenera, one based on cranial characters, one on dental characters, and one on skeletal characters aside from those of the skull.

Before taking up the osteological discussion, however, I give the histories of the various generic and subgeneric names that have been applied to the existing hares, rabbits, and pikas.

As the geographical distribution of the various groups shows some interesting correlations with zoogeographic areas, a few remarks are made on that subject.

I have had at my disposal the following skeletons:

1048 <sup>1</sup>	<i>Lepus (Lepus) timidus</i> .....	Sweden.
1049 <sup>1</sup>	<i>Lepus (Lepus) timidus</i> .....	Sweden.
49622 <sup>1</sup>	<i>Lepus (Lepus) campestris</i> .....	Nebraska.
49623 <sup>1</sup>	<i>Lepus (Lepus) campestris</i> .....	Kansas.
2276 <sup>1</sup>	<i>Lepus (Lepus) bangsii</i> .....	Newfoundland.
2277 <sup>1</sup>	<i>Lepus (Lepus) bangsii</i> .....	Newfoundland.
18303 <sup>2</sup>	<i>Lepus (Lepus) gichiganus</i> .....	Northeast Siberia.
836 <sup>1</sup>	<i>Lepus (Pæcilolagus) americanus</i> <sup>3</sup> .....	Fort Pierre, British America.
969 <sup>1</sup>	<i>Lepus (Pæcilolagus) americanus vir-</i> <i>ginianus</i> <sup>4</sup> .....	New York.
7577 <sup>1</sup>	<i>Lepus (Pæcilolagus) americanus dalli</i> <sup>6</sup> .....	Alaska.
21805 <sup>1</sup>	<i>Lepus (Macrotolagus) callotis</i> .....	Locality unknown.
94198 <sup>5</sup>	<i>Lepus (Macrotolagus) texianus</i> .....	Newark valley, Nevada.
49621 <sup>1</sup>	<i>Lepus sp.</i> .....	India; Jumna river.
49586 <sup>1</sup>	<i>Sylvilagus floridanus</i> .....	Florida.
49587 <sup>1</sup>	<i>Sylvilagus floridanus</i> .....	Florida.
49588 <sup>1</sup>	<i>Sylvilagus floridanus</i> .....	Florida.

<sup>1</sup> United States National Museum.

<sup>2</sup> American Museum of Natural History.

<sup>3</sup> Very young, of little use.

<sup>4</sup> Skeleton incomplete.

<sup>5</sup> United States National Museum, collection Biological Survey, Department of Agriculture.

<sup>6</sup> Incomplete.

49589 <sup>1</sup>	<i>Sylvilagus floridanus</i> .....	Florida.
89514 <sup>2</sup>	<i>Sylvilagus floridanus mallurus</i> .....	Four Mile Run, Virginia.
16248 <sup>1</sup>	<i>Sylvilagus floridanus mallurus</i> .....	Carlisle, Pennsylvania.
49624 <sup>1</sup>	<i>Sylvilagus floridanus transitionalis</i> ....	Monroe county, New York.
11644 <sup>1</sup>	<i>Sylvilagus nuttallii</i> .....	Fort Bridger, Wyoming.
92965 <sup>2</sup>	<i>Sylvilagus truei</i> .....	Metlatoyuca, Mexico.
113432 <sup>1</sup>	<i>Sylvilagus minensis</i> .....	Chapada, Brazil.
49665 <sup>1</sup>	<i>Sylvilagus minensis</i> , young.....	Chapada, Brazil.
74883 <sup>2</sup>	<i>Sylvilagus sp.</i> .....	Lewiston, Idaho.
94197 <sup>2</sup>	<i>Sylvilagus sp.</i> .....	Monitor valley, Nevada.
49580 <sup>1</sup>	<i>Limnolagus paludicola</i> .....	Florida.
49645 <sup>1</sup>	<i>Oryctolagus cuniculus</i> .....	Germany.
49648 <sup>1</sup>	<i>Oryctolagus cuniculus</i> .....	England.
49386 <sup>1</sup>	<i>Oryctolagus cuniculus</i> , lop-eared.....	Domestic.
49677 <sup>1</sup>	<i>Oryctolagus cuniculus</i> , Belgian hare....	United States.
57954 <sup>2</sup>	<i>Romerolagus nelsoni</i> .....	Mt. Popocatepetl, Mexico.
22972 <sup>1</sup>	<i>Pronolagus crassicaudatus</i> .....	South Africa.
93695 <sup>2</sup>	<i>Brachylagus idahoensis</i> .....	Ione valley, Idaho.
93596 <sup>2</sup>	<i>Brachylagus idahoensis</i> .....	Ione valley, Idaho.
91188 <sup>2</sup>	<i>Ochotona (Pika) saxatilis</i> .....	Cabinet mts., Idaho.
30990 <sup>2</sup>	<i>Ochotona (Pika) saxatilis</i> .....	Salmon River mts., Idaho.
49620 <sup>1</sup>	<i>Ochotona (Pika) saxatilis</i> .....	Oregon.
49500 <sup>1</sup>	<i>Ochotona (Ochotona) ladacensis</i> .....	Hanlé district, Ladak.

Besides these, I have had access to a large number of skulls, mostly of American species. These are indicated at the end of the description of each genus or subgenus.

The material examined has been altogether too limited for anything like complete work on this interesting group of rodents and much more must be compared before a satisfactory determination of various relationships can be made. Yet, in the course of study so many interesting points have been disclosed, some already published and some apparently never before recorded, that it seems advisable to set forth our present knowledge in as complete a manner as can now be done.

As an aid to a clearer understanding of the text, the following outline of the classification therein adopted is here given:

The existing Duplicidentata are considered as composed of two distinct families, the Leporidae, hares and rabbits, and the Ochotonidae, pikas.

The Leporidae are regarded as containing the following ten distinct genera, most of which have heretofore been recognized as subgenera. Two are here described as new.

<sup>1</sup> United States National Museum.

<sup>2</sup> United States National Museum, collection Biological Survey, Department of Agriculture.

1. *Lepus*, with the largest number of species and the most extensive geographical distribution. It contains three well-marked subgenera and a number of species which from lack of available material cannot now be satisfactorily classified.

(a) Subgenus *Lepus*, represented by the well-known species, *timidus*, *arcticus*, *europæus*, *campestris*, and their allies.

(b) Subgenus *Macrotolagus*; containing the jackass hares of Mexico and southwestern United States.

(c) Subgenus *Pæcilolagus* (new), containing *Lepus americanus* and the related species.

2. *Sylvilagus*, with two subgenera.

(a) *Sylvilagus* proper, containing the wood rabbits or cotton-tails of North and South America.

(b) *Microlagus*, containing a few small forms from western and southwestern United States.

3. *Oryctolagus*, represented by the rabbit of the Old World, *O. cuniculus*.

4. *Limnolagus*, containing the swamp rabbits and water hares of southern United States.

5. *Brachylagus*, a small short-tailed rabbit of western United States, *B. idahoensis*.

6. *Pronolagus* (new), containing the cape hare of South Africa.

7. *Romerolagus*, the peculiar little rabbit of Mount Popocatepetl, Mexico.

8. *Nesolagus*, from Sumatra.

9. *Caprolagus*, from the southern foothills of the Himalayas.

10. *Pentalagus* (new), from the Liu Kiu islands south of Japan.

The family Ochotonidæ contains but one existing genus, *Ochotona*, with a number of species inhabiting the northern parts or high mountain ranges of the Northern Hemisphere. It contains three well-marked subgenera.

(a) *Ochotona*, containing *ladacensis*, and allied forms from central Asia.

(b) *Pika*, containing *alpina* and the North American species.

(c) *Conothoa* (new), represented by *roylii* and related species.

In the preparation of this paper I have received from Mr. Gerrit S. Miller, Jr., many valuable suggestions and generous criticisms, which are here gratefully acknowledged. My thanks are due also to Dr. C. Hart Merriam for the use of all the skeletons and many separate skulls of the Duplicidentata in the collection of the Biological Survey of the United States Department of Agriculture; to Dr. Milton J. Greenman for the use of two specimens of *Pentalagus*



*furnessi* in the Wistar Institute of Anatomy, Philadelphia, and to Dr. J. A. Allen for the use of a skeleton of *Lepus gichiganus* and skull of *Ochotona kolymensis* in the American Museum of Natural History, New York. I have also to thank Mr. Oldfield Thomas, who presented to the U. S. National Museum a skeleton of *Oryctolagus cuniculus* and two young skeletons of *Sylvilagus minensis*; Dr. E. A. Mearns, who collected for the National Museum a series of skeletons of *Sylvilagus floridanus* and the only available skeleton of *Limnolagus*; and Messrs. Witmer Stone and James A. G. Rehn for furnishing references and copies of Blyth's figures of *Caprolagus*.

## II. LIST OF NAMES APPLIED GENERICALLY OR SUBGENER- ICALLY TO THE EXISTING HARES, RABBITS, AND PIKAS

### ABRA

Proposed by Gray (Cat. Mammals, Birds, etc., presented by B. H. Hodgson to Brit. Mus., 2d ed., p. 11, 1863) as a subgenus of *Lagomys*.

Type *Lagomys (Abra) curzoniae* HODGSON from the Himalayas of Sikkin, India.

Preoccupied by *Abra* LEACH, 1818, a genus of Mollusca, fide Palmer, North American Fauna, No. 23, pp. 71, 860, January 23, 1904.

### BRACHYLAGUS

Proposed by Miller (Proc. Biol. Soc. Washington, XIII, p. 157, June 13, 1900) as a subgenus of *Lepus* for *L. idahoensis* MERRIAM, the only species and the type. In the present paper it is considered a distinct genus.

### CAPROLAGUS

Proposed by Blyth (Journ. Asiatic Soc. Bengal, XIV, 1845, p. 247) as a genus to include *Lepus hispidus* PEARSON.

Blyth (Cat. Mam. Mus. Asiat. Soc. Calcutta, 1863, p. 133) subsequently replaced *Caprolagus hispidus* in the genus *Lepus*.

Gray (Ann. Mag. Nat. Hist., XX, 3d ser., 1867, p. 225) under the misprinted name *Carpologus* regarded it as a distinct genus for *Lepus hispidus* PEARSON.

Trouessart (Catalogus Mammalium, vol. 1, fasc. iii, p. 664, 1897) places two species under *Caprolagus* as a subgenus of *Lepus*, *hispidus* PEARSON, and *netscheri* SCHLEGEL, the latter being regarded in this paper as the type of the genus *Nesolagus* MAJOR.

Major (Trans. Linn. Soc. London, 2d ser., VII, Zool., p. 514, November, 1899) regards *Caprolagus* as a distinct genus containing the three species *sivalensis* MAJOR, *valdaruensis* WEITH, and *hispidus* PEARSON, the first two extinct. He also uses the name in a larger sense for a group, including (1) *Caprolagus*, (2) *Nesolagus*, (3) *Oryctolagus*, (4) *Sylvilagus* (the last containing (a) *Limnolagus*, (b) *Romerolagus*, (c) *Tapeti*, and (d) *Sylvilagus*), contrasted with a *Lepus* group containing the one genus *Lepus* (this the same as the genus *Lepus* of the present paper).

Stone (Proc. Acad. Nat. Sci. Philadelphia, 1900, p. 462) regards *Caprolagus* as a distinct genus containing the following species: *hispidus* PEARSON, *netscheri* SCHLEGEL, *furnessi* STONE. The last two are considered in the present paper as the types of the genera *Nesolagus* and *Pentalagus* respectively.

#### CARPOLAGUS

Used by Gray (Ann. Mag. Nat. Hist., xx, 3d ser., 1867, p. 225), typographical error, for *Caprolagus* BLYTH.

#### CHIONOBATES

Used by Kaup (Entw. Gesch. und Natur. Syst. Europ. Thierwelt, 1, p. 170, 1829) as a genus for two species, *variabilis* and *borealis*. It is antedated by *Lepus* LINNÆUS.

#### CUNICULUS

First used as a name for rabbits by Meyer (Mag. f. Thiergesch., 1, pt. i, 52-53, 1790) applied to *Oryctolagus cuniculus* (renamed by Meyer *campestris*) and *domesticus*, *angorensis*, *argenteus*, *russicus*, and *dauricus* Europe, and to *brasiliensis* Brazil.

The name is synonymous with *Lepus* LINNÆUS, containing the same three genera, *cuniculus* representative of *Oryctolagus*, *dauricus* = *tolai* (Erleben) a member of the genus *Lepus*, and *brasiliensis* a member of the genus *Sylvilagus*.

*Cuniculus* was next used by Gloger (Hand- u. Hilfsbuch Naturgesch., 1, p. 104, 1841) for *Oryctolagus cuniculus* renamed *Cuniculus dasypus*.

It was proposed again by Gray (Ann. Mag. Nat. Hist., xx, 3d ser., 1867, p. 224) as a genus for "*Lepus* Section C" Baird (Mammals of North America, 1857, p. 575). The only species included by Gray in the genus is *fodiens* KLEIN which he considered the correct name for *Lepus cuniculus* LINNÆUS, which is accordingly the type.

The name is preoccupied (*Cuniculus* BRISSON, Regn. Animal, 1762, p. 13, and *Cuniculus* WAGLER, Nat. Syst. d'Amphibian, 1830, p. 21) and was replaced by *Oryctolagus* LILLJEBORG (Sveriges och Norges Ryggradsdjur, 1, 1874, p. 417).

#### EULAGOS

Used by Gray (Ann. Mag. Nat. Hist., xx, 3d ser., 1867, p. 222) as a genus for *Lepus mediterraneus* WAGNER, and *Eulagus judææ* "the Holy Land Buneas, Tristram." The word has apparently not been used by subsequent writers, who have placed these species under the subgenus *Lepus* of the genus *Lepus*. I have seen no material of either.

#### HYDROLAGUS

Used by Gray (Ann. Mag. Nat. Hist., xx, 3d ser., 1867, p. 221) as a generic term for "*Lepus*, Section F" of Baird (Mammals of North America, p. 575). Gray places in it two species: *aquaticus* BACHMAN, and *palustris* BACHMAN. The former, the first named species and the one from which the word *Hydrolagus* was evidently derived, may be considered the type.

Trouessart (Catalogus Mammalium, 1, fasc. iii, pp. 657, 658, 1897) uses the name as a subgenus of *Lepus* for the following species: *aquaticus* BACHMAN, *aquaticus atkwateri* ALLEN, *palustris* BACHMAN, *paludicola* MILLER and

BANGS, and *truci* ALLEN. In the present paper the last named species is referred to the genus *Sylvilagus*.

As shown by Mearns (Science, n. s., v, March 5, 1897, p. 393) *Hydrolagus* GRAY, 1867, is antedated by *Hydrolagus* GILL, 1862, for a genus of fishes. (See *Limnolagus*.)

### LAGOMYS

Proposed by Cuvier (Leçons d'Anat. Comp., Table, 1800, characterized in Table élémentaire de l'histoire naturelle des animaux, p. 132, 1798) as a genus to include the animal previously known as *Lepus alpinus*, the only named species and the type.

From 1800 up to 1896 *Lagomys* was in general use among systematists as the generic term of the pikas. At the latter date Thomas (Proc. Zool. Soc. Lond., 1896, p. 1026) adopted the older name *Ochotona* LINK (Beiträge Naturgeschichte, I, pt. II, p. 74, 1795).

Under *Lagomys*, Gray (Ann. Mag. Nat. Hist., XX, 3d ser., p. 220, 1867) included the following species: Asia: *alpinus* CUVIER, *pusillus* DESMAREST, *rufescens* GRAY, *hodgsoni* BLYTH, *nepalensis* HODGSON, *roylii* OGILBY, *hyperboreus* WAGNER; America: *principis* RICHARDSON, *minimus* LORD.

*Lagomys* CUVIER is preoccupied by *Lagomys* STORR, 1780 (Prodromus Methodi Mammalium, p. 39), a substitute for the name *Arctomys* (fide Miller, North American Fauna, No. 12, p. 13, July 23, 1897).

### LAGOPSIS

Used by Rafinesque (Analyse de la Nature, 1815, addendum, p. 219) as an emendation of *Lagopsys* used on p. 58. Nomen nudum.

Used by Schlosser 1884, and Major 1899, for fossil forms.

### LAGOPSYS

Used by Rafinesque (Analyse de la Nature, 1815, p. 58). Nomen nudum, 'Lagopsys R. *Lepus* sp.; name emended to *Lagopsis*, *ibid.*, p. 219.

### LAGOS

Used in a sales catalogue by Brookes. "Cat. Anat. & Zool. Mus. of Joshua Brookes, London, p. 54, 1828."

Type: *Lagos arcticus* (= *Lepus arcticus* Ross), fide Palmer, North American Fauna, No. 23, pp. 361, 850, January 23, 1904.

This questionable name is a synonym of the restricted genus *Lepus*.

### LEPUS

Used by Linnæus, 1758 (Syst. Nat., 10th ed., I, p. 57, 1758), as a genus for four species, representing three modern genera, as follows:

*Timidus*, *Chionobates* KAUP 1829.

*Brasiliensis*, *Tapeti* GRAY = part of *Sylvilagus* GRAY 1867.

*Capensis*, *Chionobates* KAUP, 1829.

*Cuniculus*, *Cuniculus* GLOGER, 1841 (not of BRISSON, 1862) = *Oryctolagus* LILLJEBORG, 1874.

In accordance with the code of nomenclature of the American Ornithologists' Union, the species *cuniculus* would become the type, as it represents the last of the non-exotic groups to be removed.

On the other hand, by a slight extension of the rule recommended in Science, n. s., xvi, pp. 114, 115, July 18, 1902, *timidus* may be fixed as the type of the genus *Lepus*, and no radical changes in the generic names of the Leporidae would result, as would occur by a strict application of the principle of elimination.

This rule is as follows:

"A generic name which is the same as that of an explicitly included species (or a cited post-Linnæan synonym of such species) takes that species as its type regardless of subsequent elimination."

Since Linnæus could cite no post-Linnæan synonym, the rule can rationally be extended to include, in the case of Linnæus, the names used by earlier writers. Under *timidus*, Linnæus cites *Lepus* GESNER.

In the present paper, *timidus* is regarded as the type of the genus *Lepus*, and the word *Lepus* is retained for the species to which it has been commonly applied.

Pallas (Glires, 1778, pp. 1-70), Gmelin (Linnæus, Syst. Nat., 1, 1788, pp. 164-166), Schreber (Säugethiere, vii, pp. 906-918, 1792), use *Lepus* as the generic name of the pikas as well as of the hares and rabbits.

The pikas were placed in separate genera, *Ochotona* LINK, 1795 (Beiträge Naturgesch., 1, pt. ii, p. 74, 1795) and later *Lagomys* G. CUVIER, 1798 (Leçons d'Anat. Comp. Table, 1800; characterized in Tab. Élémentaire de l'Hist. Nat. des Animaux, p. 132, 1798).

From the time of Link and Cuvier until Gray in 1867, the generic name *Lepus* was used for both hares and rabbits and as the equivalent of the family Leporidae. Gray, however, divided the genus into the following genera: *Hydrolagus*, *Sylvilagus*, *Eulagos*, *Lepus*, *Tapeti*, and *Cuniculus*. At the same time he revived Blyth's genus *Caprolagus* (under the misprint *Carpolagus*) which had been proposed in 1845 and subsequently withdrawn by Blyth.

Gray included in the genus *Lepus* the following species:

European.—*timidus* LINNÆUS, *hybridus* DESMAREST, *aquilonius* BLASIUS, *variabilis* PALLAS, *canescens* NILSSON.

African.—*egyptius* GEOFFROY, *hebesinicus* HEMPRICH and EHRENBERG, *isabellinus* RÜPPELL, *capensis* LINNÆUS, *saxatilis* F. CUVIER, *crassicaudatus* I. GEOFFROY.

Asiatic.—*arabicus* HEMPRICH and EHRENBERG, *syriacus* HEMPRICH and EHRENBERG, *siniticus* HEMPRICH and EHRENBERG, *nigricollis* F. CUVIER, *ruficaudatus* I. GEOFFROY, *tolai* PALLAS, *tibetanus* WATERHOUSE, *pallipes* HODGSON, *brachyurus* TEMMINCK, *sincensis* GRAY, *altaicus* BRANDT.

American.—*arcticus* LEACH, *americanus* ERXLEBEN, *washingtonii* BAIRD, *campestris* BACHMAN, *callotis* WAGNER, *californicus* GRAY, *longicaudatus* GRAY, *audubonii* BAIRD, *trovbridgii* BAIRD.

Of these *crassicaudatus* is regarded in this paper as the type of the genus *Pronolagus* and *audubonii* and *trovbridgii* as members of the genus *Sylvilagus*.

From 1867 to 1896 not much attention was paid to Gray's division of *Lepus*, but in 1896 Mearns revived *Sylvilagus* and *Hydrolagus* as subgenera of *Lepus*.

In the same year, 1896, Merriam described *Romerolagus* as a new genus of the Leporidae, regarding all the other members of the family as congeneric. From that time on the idea has rapidly spread that the family Leporidae no longer could be regarded as composed of but a single genus. In 1899 Major

revived Gray's names and Blyth's *Caprolagus* and gave one new name, *Nesolagus*.

Trouessart (Catalogus Mammalium, 1, fasc. iii, 1897, pp. 649-664) gives two genera of the Leporidae, *Romerlagus* and *Lepus*. *Lepus* contains the following subgenera: *Lepus*, *Hydrolagus*, *Sylvilagus*, *Microlagus*, *Macrotolagus*, *Tapeti*, *Oryctolagus*, and *Caprolagus*. All of these except *Lepus* are discussed elsewhere.

Under *Lepus* as a subgenus Trouessart includes the following species: *timidus* LINNÆUS, *europæus* PALLAS, *mediterraneus* WAGNER, *tolai* PALLAS, *mandschuricus* RADDE, *yarkandensis* GÜNTHER, *oiostolus* HODGSON, *pallipes* HODGSON, *dayanus* BLANFORD, *nigricollis*, F. CUVIER, *ruficaudatus* IS. GEOFFROY, *peguensis* BLYTH, *sinensis* GRAY, *hypsibius* BLANFORD, *swinhoi* THOMAS, *hainanus* SWINHOE, *brachyurus* TEMMINCK, *omanensis* THOMAS, *arabicus* HEMPRICH and EHRENBERG, *judæa* GRAY, *sinaiticus* HEMPRICH and EHRENBERG, *ægyptius* AUDOUIN and GEOFFROY, *somalensis* HEUGLIN, *berberanus* HEUGLIN, *tigrensis* BLANFORD, *microtis* HEUGLIN, *capensis* LINNÆUS, *whytei* THOMAS, *victoria* THOMAS, *crassicaudatus* IS. GEOFFROY, *saxatilis* F. CUVIER, *salæ* JENTINK, *arcticus* LEACH, *grønlandicus* RHOADS, *tshuktschorum* NORQUIST, *americanus* ERXLÉBEN, *campestris* BACHMAN.

Of these, *crassicaudatus* is regarded as the type of a new genus *Pronolagus* in the present paper. Many of the others I have not examined, nor seen figures of them, but those of which specimens and figures are available undoubtedly belong to the genus *Lepus* as defined further on.

Major (Trans. Linn. Soc. London, 2d ser., VII, Zool., p. 541, November, 1899) uses *Lepus* as a genus for evidently the same species that Trouessart includes in his subgenera *Lepus* and *Macrotolagus*.

Miller and Rehn (Proc. Boston Soc. Nat. Hist., xxx, pp. 177-180, December 27, 1901) have included under the subgenus *Lepus*, the following: *americanus* ERXLÉBEN, *americanus bairdii* HAYDEN, *americanus columbiensis* RHOADS, *americanus dalli* MERRIAM, *americanus macfarlandi* MERRIAM, *americanus phæconotus* ALLEN, *americanus struthopus* BANGS, *americanus virginianus* HARLAN, *arcticus* ROSS, *arcticus bangsii* RHOADS, *bishopi* ALLEN, *campestris* BACHMAN, *grønlandicus* RHOADS, *klamathensis* MERRIAM, *labradorius* MILLER, *othus* MERRIAM, *podromus* MERRIAM, *washingtonii* BAIRD.

In the present paper the genus *Lepus* corresponds in general with Trouessart's and Miller and Rehn's subgenera *Lepus* and *Macrotolagus*. I regard it as composed of a number of species whose relationships cannot be determined at the present time, and at least three distinct subgenera, (a) *Lepus*, including *arcticus*, *arcticus bangsii*, *campestris*, *grønlandicus*, *labradorius*, *othus*, and *podromus* of Miller and Rehn's list, together with *europæus*, *timidus*, and related forms of the Old World; (b) *Pacilolagus*, containing *americanus* and its subspecies, together with *bishopi*, *klamathensis*, and *washingtonii*; and (c) *Macrotolagus*, with the species included under that name by Trouessart and by Miller and Rehn.

#### LIMNOLAGUS

Proposed by Mearns (Science, n. s., v, March 5, 1897, p. 393) to replace *Hydrolagus* GRAY (Ann. Mag. Nat. Hist., xx, 3d ser., 1867, p. 221) preoccupied in ichthyology by *Hydrolagus* GILL (Proc. Acad. Nat. Sci. Philadelphia, 1862, p. 331). Type designated as *Lepus aquaticus* BACHMAN.

Major (Trans. Linn. Soc. London, 2d ser., VII, Zool., November, 1899, p. 514) uses it as a subgenus of *Sylvilagus* for "*S. palustris, aquaticus, &c.*"

Miller and Rehn (Proc. Boston Soc. Nat. Hist., xxx, pp. 183-184, December 27, 1901) have included under *Limnolagus* as a subgenus of *Lepus* the following species: *aquaticus* BACHMAN, *aquaticus attwateri* ALLEN, *palustris* BACHMAN, *palustris paludicola* MILLER and BANGS, *telmalemonus* ELLIOT, and *truci* ALLEN.

I consider *Limnolagus* as a genus embracing all the species just mentioned as found in Miller and Rehn, except *truci* ALLEN which is a member of the genus *Sylvilagus*.

#### MACROTOLAGUS

Proposed by Mearns (Sci., N. S. I., p. 698, June 21, 1895; Proc. U. S. N. M., XVIII, p. 552, June 24, 1896) as a subgenus of *Lepus* for the jackass hares of southwestern United States and Mexico. *Lepus alleni* MEARN'S is designated as the type. The following species are included by him in this subgenus: *callotis*, *gaillardi*, *alleni* (type), *merriami*, *melanotis*, *griseus*, *texianus*, *eremicus*, *deserticola*, and *californicus*.

Trouessart (Catalogus Mammalium, I, fasc. iii, 1897, pp. 660-662) includes under *Macrotolagus* as a subgenus of *Lepus*, the following species: *alleni* MEARN'S, *callotis* WAGLER, *gaillardi* MEARN'S, *merriami* MEARN'S, *melanotis* MEARN'S, *texianus* WATERHOUSE (including the subspecies *eremicus* ALLEN, *griseus* MEARN'S, and *deserticola* MEARN'S) *californicus* GRAY, *martirensis* STOWELL, *insularis* BRYANT.

The term is used by Major (Trans. Linn. Soc. London, 2d ser., VII, Zool., pp. 468, 469, November, 1899) as a subgenus of *Lepus*, for apparently the same group of hares that Mearns applied it to.

Miller and Rehn (Proc. Boston Soc. Nat. Hist., xxx, pp. 180-183, December 27, 1901) place in the subgenus *Macrotolagus* the following species: *alleni* MEARN'S, *alleni palitans* BANGS, *asellus* MILLER, *californicus* GRAY, *californicus xanti* THOMAS, *callotis* WAGLER, *gaillardi* MEARN'S, *insularis* BRYANT, *martirensis* STOWELL, *melanotis* MEARN'S, *merriami* MEARN'S, *texianus* WATERHOUSE, *texianus deserticola* MEARN'S, *texianus eremicus* ALLEN, *texianus griseus* MERRIAM.

It is used in the present paper in the same sense as by Miller and Rehn.

It is interesting to note that the hares of this subgenus were recognized by Baird (Mammals of North America, p. 574, 1857) as forming a distinct group and constituting his "*Lepus* Section B."

#### MAMLEPUS

Used by A. L. Herrera (Sinonimia vulgar y científica de los principales vertebrados mexicanos, p. 11, 1899) as a name in a new system of nomenclature for the broad genus *Lepus* of Linnæan nomenclature.

#### MICROLAGUS

Proposed by Trouessart (Catalogus Mammalium, I, fasc. iii, p. 660, 1897) as a subgenus of *Lepus* for *Lepus cinerascens* ALLEN, on characters defined by Mearns (Proc. U. S. Nat. Mus., XVIII, pp. 552, 553, June 24, 1896). *Cinerascens* ALLEN, the only species named by Trouessart, is the type.

It is used by Miller and Rehn (Proc. Bost. Soc. Nat. Hist., xxx, pp. 188, 189) as a subgenus of *Lepus* for the following species: *bachmani* WATER-

HOUSE, *bachmani ubericolor* MILLER, *cerrosensis* ALLEN, *cinerascens* ALLEN, *peninsularis* ALLEN.

In the present paper it is regarded as a subgenus of *Sylvilagus*, and includes the species just mentioned as recorded by Miller and Rehn.

Baird (Mammals of North America, p. 575, 1857) recognized that the members of this subgenus formed a distinct group included under his section E.

#### MICROTOLAGUS

A curious misprint for *Macrotolagus* MEARNS found in Elliot (Synopsis of Mammals of North America and adjacent Seas, Field Columbian Mus., Zool. Ser. II, pp. 269, 288, 1901), repeated by Allen (Bull. Amer. Mus. Nat. Hist., p. 607, 1903).

#### MNUOLAGUS

Billberg (Syn. Faunæ Scandinaviæ, I, Mamm., Conspectus A. (before p. 1), 1828). Nomen nudum, occurring only in a table between *Lagomys* and *Lepus*, fide Palmer, North American Fauna, No. 23, January 23, 1904, pp. 850, 951.

#### NESOLAGUS

Proposed by Major (Trans. Linn. Soc. London, 2d ser., VII, Zool., p. 514, November, 1899) as a genus under the *Caprolagus* group (or a subgenus of the genus *Caprolagus*; Major does not definitely state) for *Lepus netscheri* SCHLEGEL (Notes Leyden Museum, II, 1880, pp. 59-65).

*Netscheri* is the only mentioned species and the type.

*Nesolagus* is here regarded as a well-marked genus.

#### OCHOTONA

First used by Link, 1795 (Beiträge Naturgeschichte, I, pt. II, p. 74, 1795) as the generic name of the pikas. The following species are given: *pusilla*, *alpina*, and *minor* (*Lepus Ochotona*) LINNÆUS, of which *ochotona* is the type, *dauricus* is an earlier name, however, for the same species. (See Palmer, N. A. Fauna, No. 23, p. 468, January 23, 1904.)

It is the proper generic name of the pikas, for nearly a century called *Lagomys* CUVIER (Leçons d'Anat. Comp. Table, 1800) owing to ignorance of Link's rare work. Thomas (Proc. Zool. Soc. Lond., 1896, p. 1026) seems to have been the first to have brought forward Link's name.

It is used in the present paper as a genus for the pikas and also as a subgeneric name for *Ochotona ladacensis* and related species.

#### OGOTOMA

First used by Gray in 1867 (Ann. Mag. Nat. Hist., XX, 3d ser., p. 220, 1867) as the generic name for *Lagonys ogotoma* of Cuvier and of Waterhouse, the *Lepus ogotoma* PALLAS. Gray changes the specific name to *pallasii*. As this is the only species placed in the genus by Gray, it is the type.

The term is antedated by *Ochotona* LINK (Beiträge Naturgesch., I, pt. II, p. 74, 1795), which has the same species for the type.

#### ORYCTOLAGUS

Proposed by Lilljeborg (Sveriges och Norges Ryggradsdjur, I, p. 417, 1874) as a subgeneric name for *Lepus cuniculus* LINNÆUS which is designated as the type. It was used to replace *Cuniculus* GRAY (Ann. Mag. Nat. Hist., 3d ser., XX, p. 225) which is preoccupied by *Cuniculus* WAGLER (Nat. Syst. d'Amphibian, p. 21, 1830), and BRISSON (Regn. Animal, 1762).

Trouessart (Catalogus Mammalium, I, fasc. iii, p. 663, 1897) uses it as a subgenus for *Lepus cuniculus* LINNÆUS, the only existing species.

Major (Trans. Linn. Soc. London, 2d ser., VII, Zool., November, 1899, p. 514) regards it as a genus containing two species "*O. cuniculus* (LINN.); *O. crassicaudatus* (GEOFFR.)." In the present paper the latter is regarded as the type of the genus *Pronolagus*.

Recently Thomas (Ann. Mag. Nat. Hist., ser. 7, XI, January, 1903, pp. 78, 79) following Major has used *Oryctolagus* in a generic sense.

In the present paper it is regarded as a genus for the rabbits, heretofore commonly known as *Lepus cuniculus*.

### PICA

Proposed by Fischer (Das National Museum Naturgesch. zu Paris, II, 126, 1803) as a correction of *Pika* LACÉPÈDE, fide Palmer (North American Fauna, No. 23, January 23, 1904, p. 537).

### PIKA

Used by Lacépède in 1799 (Tableau des Divisions de Mammifères, 1799, p. 9) for the Alpine pika, called *Pika alpinus*, the only mentioned species, and accordingly the type.

It is used in the present account as a subgeneric term to include *Ochotona* (*Pika*) *alpina* and its related species, embracing all the North American forms.

### ROMEROLAGUS

Proposed by Merriam (Proc. Biol. Soc. Washington, X, December 29, 1896, p. 173) as a genus for a remarkable rabbit found on the west slope of Mount Popocatepetl, Mexico. The type and only species in the genus is *Romerolagus nelsoni* MERRIAM.

Herrera (Mem. Revista de la Soc. Cient. Antonio Alzate, XIV, 1899-1900, p. 380; La Naturaleza, 2d ser., tomo III, 1898, p. 80) considers *Romerolagus nelsoni* to be a member of the genus *Lagomys*, a view which is entirely untenable (Nelson, Soc. Científica Antonio Alzate Mex., Revista Científica y Bibliográfica, num. 3, 1901, p. 33, figs. 1-6).

Major (Trans. Linn. Soc. London, 2d ser. VII, Zool., November, 1899, p. 514) regards *Romerolagus* as one of four subgenera of *Sylvilagus*, the other three being *Tapeti*, *Limnolagus* and true *Sylvilagus*.

Stone (Proc. Acad. Nat. Sci. Philadelphia, 1900, p. 462) regards it as one of three genera forming the Leporidae, the other two being *Caprolagus* and *Lepus*.

*Romerolagus* is here recognized as a well-marked genus of the family Leporidae.

### SYLVILAGUS

This was first proposed by Gray (Ann. Mag. Nat. Hist., 3d ser., XX, 1867, p. 221) as a generic term for "*Lepus* Section D" of Baird (Mammals of North America, 1857, p. 578). The species first mentioned by Gray is *Sylvilagus nanus* (SCHREBER), a synonym of *Sylvilagus sylvaticus* (BACHMAN), whose specific name was undoubtedly the origin of the word *Sylvilagus*. It is evident that Gray had Baird's account in mind and merely copied the synonymy of *Sylvilagus sylvaticus* as given by Baird, and in this way he happened to use Schreber's name *nanus*. As the animal formerly known as *Sylvilagus*



*sylvaticus* has had to be renamed *Sylvilagus floridanus mallurus* (Thomas, Ann. Mag. Nat. Hist., 7th ser., II, October, 1898, p. 320; Allen, Bull. Amer. Mus. Nat. Hist., XII, March 4, 1899, p. 13), the latter becomes the type of the genus *Sylvilagus*.

Two other species were placed in this genus by Gray, *artemisia* BACHMAN, and *bachmani* WATERHOUSE.

The name has generally been used by subsequent writers as the subgeneric term for the cottontail rabbits (*Sylvilagus floridanus* and its allies) of North America.

Major (Trans. Linn. Soc. London, 2d ser., VII, Zool., November, 1899, p. 514) uses it in a generic sense for *Limnolagus* MEARN'S, *Romerolagus* MERRIAM (both regarded as separate genera in the present account), *Tapeti* GRAY (which I regard as a part of *Sylvilagus*), and *Sylvilagus* GRAY, which according to Major embraces "*S. sylvaticus*, etc."

Trouessart (Catalogus Mammalium, I, fasc. II, pp. 658-660, 1897) uses it in a subgeneric sense for the following species: *sylvaticus* BACHMAN (with the subspecies: *transitionalis* BANGS, *bachmani* WATERHOUSE, *alacer* BANGS, *mearnsi* ALLEN, *floridanus* ALLEN, *pinetis* ALLEN, *arizona* ALLEN, *holzneri* MEARN'S, *nuttalli* BACHMAN, *auduboni* BAIRD, *aztecus* ALLEN), *grangeri* ALLEN, *troxbridgei* BAIRD, *artemisia* BACHMAN, *arizona* ALLEN (with the subspecies *major* MEARN'S and *minor* MEARN'S), *veracrucis* THOMAS, *insolitus* ALLEN, *orizaba* MERRIAM, *graysoni* ALLEN, *idahoensis* MERRIAM.

Of these the last I regard as the only member of the genus *Brachylagus* proposed by Miller as a subgenus, and *troxbridgii* BAIRD as a member of the subgenus *Microlagus* of the genus *Sylvilagus*.

Miller and Rehn (Proc. Boston Soc. Nat. Hist., XXX, December 27, 1901, 184-188) have included under *Sylvilagus*, as a subgenus of *Lepus*, the following species: *arizona* ALLEN, *arizona confinis* ALLEN, *arizona major* MEARN'S, *arizona minor* MEARN'S, *baileyi* MERRIAM, *floridanus* ALLEN, *floridanus alacer* BANGS, *floridanus audubonii* BAIRD, *floridanus aztecus* ALLEN, *floridanus canicinctus* MILLER, *floridanus chapmani* ALLEN, *floridanus holzneri* MEARN'S, *floridanus mallurus* THOMAS, *floridanus mearnsi* ALLEN, *floridanus pinetis* ALLEN, *floridanus rigidus* MEARN'S, *floridanus sanctidiegi* MILLER, *floridanus subcinctus* MILLER, *floridanus transitionalis* BANGS, *floridanus yucatanicus* MILLER, *grangeri* ALLEN, *graysoni* ALLEN, *insolitus* ALLEN, *nuttalli* BACHMAN, *orizaba* MERRIAM, *veracrucis* THOMAS.

Recently Thomas (Ann. Mag. Nat. Hist., ser. 7, VIII, December, 1901, pp. 534, 539) following Major has raised *Sylvilagus* to generic rank.

I consider *Sylvilagus* a distinct genus, embracing all the forms given by Miller and Rehn under their subgenera *Sylvilagus*, *Microlagus*, and *Tapeti* (also including *Lepus truci* ALLEN, which is found in their list under the subgenus *Limnolagus*) and all the South American Leporidae. It is also used in the present paper as a subgeneric term for all the species of *Sylvilagus* just mentioned, except the group embracing *Microlagus* here regarded as another subgenus of *Sylvilagus*.

#### TAPETI

Proposed by Gray (Ann. Mag. Nat. Hist., 3d ser., XX, 1867, p. 224) as a generic term for *Lepus brasiliensis* LINNÆUS, which, as the only named species, is the type.

Trouessart (Catalogus Mammalium, 1, fasc. iii, 1897, pp. 662-663) places the following species under it used as a subgenus, *gabbi* ALLEN, *defilippii* CORNELIA, *nigronuchalis* HARTERT, *brasiliensis* LINNÆUS.

Miller and Rehn (Proc. Boston Soc. Nat. Hist., xxx, p. 190, December 27, 1901) have included under it (as a subgenus of *Lepus*) *brasiliensis* LINNÆUS and *gabbi* ALLEN.

Major (Trans. Linn. Soc. London, 2d ser., vii, Zool., November, 1899, p. 514) regards *Tapeti* as one of four subgenera (the other three being *Limnolagus*, *Romerolagus*, and true *Sylvilagus*) forming the genus *Sylvilagus*.

Gray describes *Tapeti* as follows: "Skull like *Lepus*, but with hinder supraorbital notch narrow, the lobes short, with a sharp inner edge; the front of the lower edge of the zygoma dilated, sharp-edged, porous above, hinder nasal opening rather narrower. Tail, none. Ears short." This description of the skull does not agree with the skulls of *Sylvilagus minensis*, *paraguensis* or *gabbi* at hand, and I am at a loss to understand the true status of *Tapeti*. The available material shows that *Tapeti* is nothing else than a part of *Sylvilagus*, and it is so here regarded.

### III. LIST OF THE EXISTING SPECIES OF THE DUPLICIDEN-TATA ARRANGED BY GENERA AND SUBGENERA

The species under each group are arranged alphabetically. The list includes all the names that are found in Trouessart's Catalogus Mammalium, 1897, and in Miller and Rehn's Systematic Results of the Study of North American Land Mammals to the Close of the Year 1900 (Proc. Boston Soc. Nat. Hist., xxx, December 27, 1901) together with the names that have appeared since these two works. Those species of which the writer has seen skulls or skeletons are printed in small capitals, those of which he has seen figures of the skulls or skeletons are in italic, and those of which he has seen neither specimens nor figures are in ordinary type.

- LEPUS (LEPUS) ARCTICUS Ross.  
 LEPUS (LEPUS) ARCTICUS BANGSH Rhoads.  
 LEPUS (LEPUS) ARCTICUS CANUS Preble.  
 LEPUS (LEPUS) CAMPESTRIS Bachman.  
 Lepus (Lepus) corsicanus de Winton.  
 Lepus (Lepus) creticus Barrett-Hamilton.  
 Lepus (Lepus) cyprinus Barrett-Hamilton.  
 LEPUS (LEPUS) EUROPÆUS Pallas.  
 LEPUS (LEPUS) GICHIGANUS Allen.  
 LEPUS (LEPUS) GRÖNLANDICUS Rhoads.  
 LEPUS (LEPUS) LABRADORIUS Miller.  
 Lepus (Lepus) lilfordi de Winton.  
 LEPUS (LEPUS) OTHUS Merriam.  
 LEPUS (LEPUS) PARNASSIUS Miller.  
 LEPUS (LEPUS) PODROMUS Merriam.  
 LEPUS (LEPUS) TIMIDUS Linnæus.  
 Lepus (Lepus) timidus ainu Barrett-Hamilton.  
 Lepus (Lepus) timidus lutescens Barrett-Hamilton.  
 Lepus (Lepus) transylvanicus Matschie.  
 LEPUS (LEPUS) VARRONIS Miller.  
 LEPUS (PŒCILLAGUS) AMERICANUS Erxleben.

- LEPUS (PŒCILOLAGUS) AMERICANUS BAIRDII (Hayden).  
 Lepus (Pœcilolagus) americanus columbiensis Rhoads.  
 LEPUS (PŒCILOLAGUS) AMERICANUS DALLI Merriam.  
 LEPUS (PŒCILOLAGUS) AMERICANUS MACFARLANI Merriam.  
 Lepus (Pœcilolagus) americanus phæonotus Allen.  
 LEPUS (PŒCILOLAGUS) AMERICANUS STRUTHOPUS Bangs.  
 LEPUS (PŒCILOLAGUS) AMERICANUS VIRGINIANUS (Harlan).  
 Lepus (Pœcilolagus) bishopi Allen.  
 LEPUS (PŒCILOLAGUS) KLAMATHENSIS Merriam.  
 LEPUS (PŒCILOLAGUS) SALIENS Osgood.  
 LEPUS (PŒCILOLAGUS) WASHINGTONII Baird.  
  
 LEPUS (MACROTOLAGUS) ALLENI Mearns.  
 Lepus (Macrotolagus) alleni palitans Bangs.  
 LEPUS (MACROTOLAGUS) ASELLUS Miller.  
 LEPUS (MACROTOLAGUS) CALIFORNICUS Gray.  
 Lepus (Macrotolagus) californicus xanti Thomas.  
 LEPUS (MACROTOLAGUS) CALLOTIS Wagler.  
 LEPUS (MACROTOLAGUS) GAILLARDI Mearns.  
 Lepus (Macrotolagus) gaillardi battyi Allen.  
 LEPUS (MACROTOLAGUS) INSULARIS Bryant.  
 Lepus (Macrotolagus) martirensis Stowell.  
 LEPUS (MACROTOLAGUS) MELANOTIS Mearns.  
 LEPUS (MACROTOLAGUS) MERRIAMI Mearns.  
 LEPUS (MACROTOLAGUS) TENIANUS Waterhouse.  
 LEPUS (MACROTOLAGUS) TENIANUS DESERTICOLA Mearns.  
 LEPUS (MACROTOLAGUS) TENIANUS EREMICUS Allen.  
 LEPUS (MACROTOLAGUS) TENIANUS GRISEUS Mearns.  
 Lepus (Macrotolagus) texianus micropus Allen.  
  
 Lepus ægyptius Audouin and Geoffroy.  
 Lepus arabicus Hemprich and Ehrenberg.  
 Lepus atlanticus de Winton.  
 Lepus berberanus Heuglin.  
 Lepus brachyurus Temminck.  
 LEPUS CAPENSIS Linnæus.  
 Lepus capensis centralis Thomas.  
 LEPUS CAPENSIS OCHROPUS Wagner.  
 Lepus crawshayi de Winton.  
 Lepus dayanus Blandford.  
 Lepus etruscus Bosco.  
 Lepus fagani Thomas.  
 Lepus hainanus Swinhoe.  
 Lepus harterti Thomas.  
 Lepus hawkeri Thomas.  
 LEPUS HYPSEBIUS Blandford.  
 Lepus judeæ Gray.  
 Lepus kabylicus de Winton.  
 Lepus mandschuricus Radde.  
 Lepus mediterraneus Wagner.  
 Lepus microtis Heuglin.  
 Lepus monticularis Thomas.  
 Lepus nigricollis F. Cuvier.  
 Lepus oiostolus Hodgson.  
 Lepus omanensis Thomas.  
 Lepus pallidor Barrett-Hamilton.  
 Lepus pallipes Hodgson.  
 Lepus peguensis Blyth.  
 LEPUS RUFICAUDATUS Is. Geoffroy.  
 Lepus salae Jentink.  
 Lepus saxatilis F. Cuvier.  
 Lepus schlumbergeri St. Loup.  
 Lepus sechuensis de Winton.  
 Lepus siamensis Bonhote.

*Lepus sinaiticus* Hemprich and Ehrenberg.  
 LEPUS SINENSIS Gray.  
*Lepus somalensis* Heuglin.  
*Lepus swinhoei* Thomas.  
*Lepus syriacus* Hemprich and Ehrenberg.  
 LEPUS TIGRENSIS Blanford.  
*Lepus tolai* Pallas.  
*Lepus tunetæ* de Winton.  
*Lepus victoriæ* Thomas.  
*Lepus whitakeri* Thomas.  
*Lepus whytei* Thomas.  
 LEPUS YARKANDENSIS Günther.  
*Lepus zechi* Matschie.

ORYCTOLAGUS CUNICULUS (Linnæus).

*Sylvilagus* (*Sylvilagus*) *andinus* (Thomas).  
 SYLVILAGUS (*Sylvilagus*) *arizonæ* (Allen).  
*Sylvilagus* (*Sylvilagus*) *arizonæ confinis* (Allen).  
 SYLVILAGUS (*Sylvilagus*) *arizonæ major* (Mearns).  
 SYLVILAGUS (*Sylvilagus*) *arizonæ minor* (Mearns).  
 SYLVILAGUS (*Sylvilagus*) *baileyi* (Merriam).  
*Sylvilagus* (*Sylvilagus*) *braziliensis* (Linnæus).  
*Sylvilagus* (*Sylvilagus*) *cumanicus* (Thomas).  
*Sylvilagus* (*Sylvilagus*) *defilippii* (Cornalia).  
*Sylvilagus* (*Sylvilagus*) *durangæ* (Allen).  
 SYLVILAGUS (*Sylvilagus*) *floridanus* (Allen).  
*Sylvilagus* (*Sylvilagus*) *floridanus alacer* (Bangs).  
 SYLVILAGUS (*Sylvilagus*) *floridanus audubonii* (Baird).  
 SYLVILAGUS (*Sylvilagus*) *floridanus aztecus* (Allen).  
 SYLVILAGUS (*Sylvilagus*) *floridanus caniclunis* (Miller).  
 SYLVILAGUS (*Sylvilagus*) *floridanus chapmani* (Allen).  
 SYLVILAGUS (*Sylvilagus*) *floridanus holzneri* (Mearns).  
 SYLVILAGUS (*Sylvilagus*) *floridanus mallurus* (Thomas).  
 SYLVILAGUS (*Sylvilagus*) *floridanus mearnsi* (Allen).  
*Sylvilagus* (*Sylvilagus*) *floridanus persultator* (Elliot).  
*Sylvilagus* (*Sylvilagus*) *floridanus pinetis* (Allen).  
 SYLVILAGUS (*Sylvilagus*) *floridanus rigidus* (Mearns).  
 SYLVILAGUS (*Sylvilagus*) *floridanus sanctidiegi* (Miller).  
 SYLVILAGUS (*Sylvilagus*) *floridanus subcinctus* (Miller).  
 SYLVILAGUS (*Sylvilagus*) *floridanus transitionalis* (Bangs).  
 SYLVILAGUS (*Sylvilagus*) *floridanus yucatanicus* (Miller).  
 SYLVILAGUS (*Sylvilagus*) *gabbi* (Allen).  
*Sylvilagus* (*Sylvilagus*) *grangeri* (Allen).  
 SYLVILAGUS (*Sylvilagus*) *graysoni* (Allen).  
*Sylvilagus* (*Sylvilagus*) *incitatus* (Bangs).  
 SYLVILAGUS (*Sylvilagus*) *insolitus* (Allen).  
*Sylvilagus* (*Sylvilagus*) *laticinctus* (Elliot).  
*Sylvilagus* (*Sylvilagus*) *laticinctus rufipes* (Elliot).  
 SYLVILAGUS (*Sylvilagus*) *margaritæ* (Miller).  
 SYLVILAGUS (*Sylvilagus*) *minensis* Thomas.  
*Sylvilagus* (*Sylvilagus*) *nigronuchalis* (Hartert).  
 SYLVILAGUS (*Sylvilagus*) *nuttallii* (Baclunan).  
*Sylvilagus* (*Sylvilagus*) *orinoci* Thomas.  
 SYLVILAGUS (*Sylvilagus*) *orizabæ* (Merriam).  
 SYLVILAGUS (*Sylvilagus*) *paraguensis* Thomas.  
*Sylvilagus* (*Sylvilagus*) *parvulus* (Allen).  
*Sylvilagus* (*Sylvilagus*) *russatus* (Allen).  
 SYLVILAGUS (*Sylvilagus*) *simplicanus* (Miller).  
*Sylvilagus* (*Sylvilagus*) *superciliaris* (Allen).  
*Sylvilagus* (*Sylvilagus*) *surdaster* Thomas.  
 SYLVILAGUS (*Sylvilagus*) *truei* (Allen).  
 SYLVILAGUS (*Sylvilagus*) *veræcrucis* (Thomas).  
 SYLVILAGUS (*Microlagus*) *bachmani* (Waterhouse).

SYLVILAGUS (MICROLAGUS) BACHMANI UBERICOLOR (Miller).

Sylvilagus (Microlagus) cerrosensis (Allen).

SYLVILAGUS (MICROLAGUS) CINERASCENS (Allen).

Sylvilagus (Microlagus) peninsularis (Allen).

LIMNOLAGUS AQUATICUS (Bachman).

LIMNOLAGUS AQUATICUS ATTWATERI (Allen).

LIMNOLAGUS PALUSTRIS (Bachman).

LIMNOLAGUS PALUSTRIS PALUDICOLA (Miller and Bangs).

*Limnolagus tchmalemonus* (Elliot).

BRACHYLAGUS IDAHOENSIS (Merriam).

*Caprolagus hispidus* (Pearson).

PRONOLAGUS CRASSICAUDATUS (Is. Geoffroy).

Pronolagus crassicaudatus curryi (Thomas).

Pronolagus crassicaudatus nyikæ (Thomas).

ROMEROLAGUS NELSONI Merriam.

*Nesolagus netscheri* (Jentink).

PENTALAGUS FURNESSI (Stone).

Ochotona (Ochotona) curzoniæ (Hodgson).

Ochotona (Ochotona) daurica (Pallas).<sup>1</sup>

*Ochotona (Ochotona) kosłowi* Büchner.

OCHOTONA (OCHOTONA) LADACENSIS Günther.

Ochotona (Ochotona) melanostoma Büchner.

*Ochotona (Pika) alpina* (Pallas).

OCHOTONA (PIKA) COLLARIS (Nelson).

OCHOTONA (PIKA) CUPPES Bangs.

Ochotona (Pika) hyperboreus (Pallas).

OCHOTONA (PIKA) KOLYMENSIS Allen.

Ochotona (Pika) littoralis (Peters).

OCHOTONA (PIKA) PRINCEPS (Richardson).

Ochotona (Pika) pusilla (Pallas).

OCHOTONA (PIKA) SAXATILIS Bangs.

OCHOTONA (PIKA) SCHISTICEPS (Merriam).

*Ochotona (Conothoa) erythrotis* Büchner.

OCHOTONA (CONOTHOA) ROYLEI (Ogilby).

Ochotona rufescens (Gray).

Ochotona rutila (Severzow).

#### IV. GENERAL CONSIDERATION OF THE SKELETON AND TEETH OF THE DUPLICIDENTATA

##### SKULL

The skulls of the two families Ochotonidæ and Leporidæ are widely different in nearly every respect, and were it not for the structure of the teeth and the number of the upper incisors there would be little to indicate that the two groups were closely related. The skulls of members of both of these families have so often been described and figured that there is here no need of a general description of that important part of their osteology, which will be given later in regard to less well known parts.

<sup>1</sup> An earlier name for *ochotona* the type.

## LEPORIDÆ

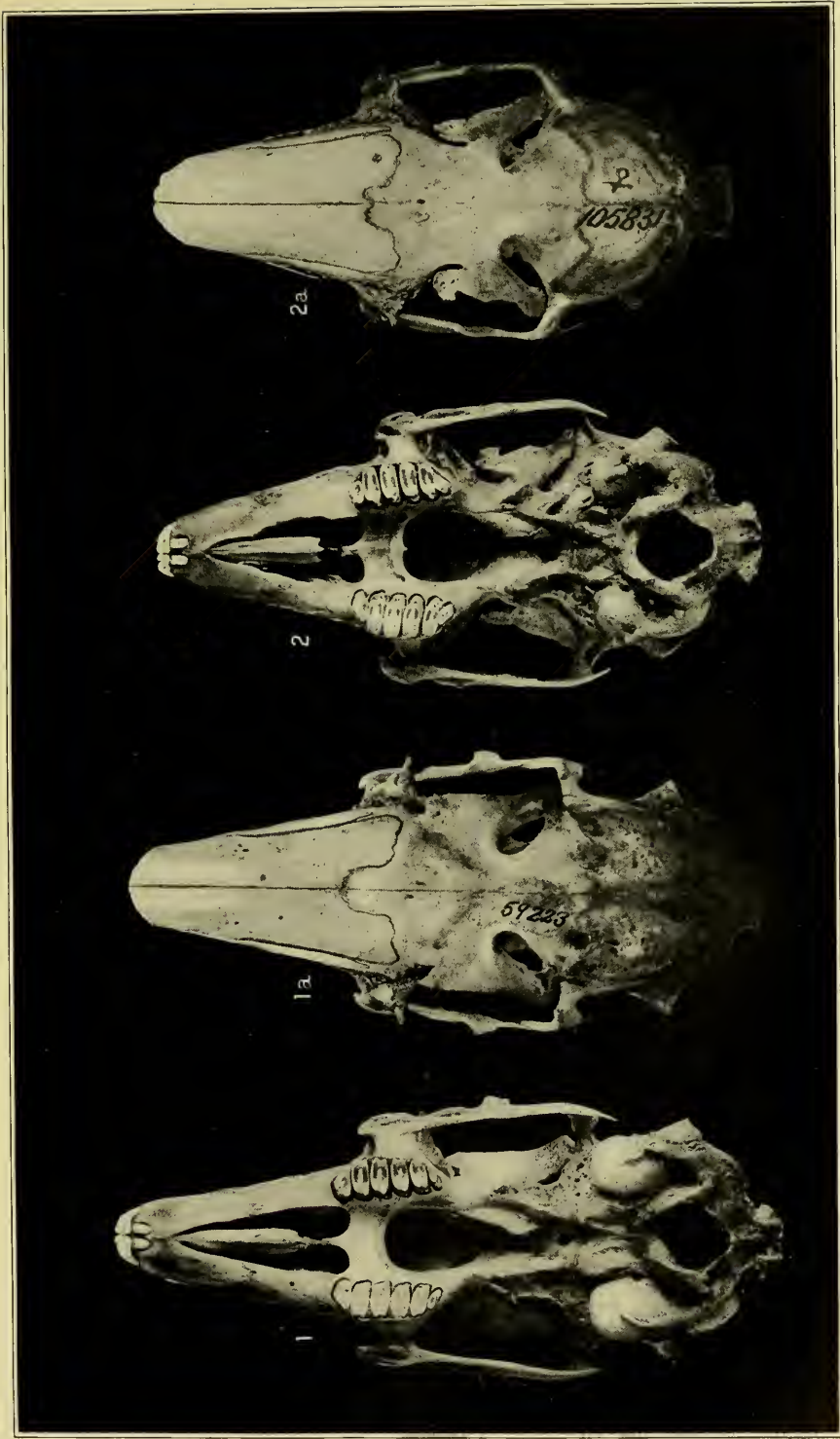
(PLATES LXXIV-LXXXIX)

The skulls of the Leporidæ fall into several groups, each distinct from the other, and no specimens have been seen which show intermediate conditions between any two of the divisions. The variations upon which these groups are founded consist principally in the shape, size, and method of the attachment of the postorbital processes, the distinctness of the interparietal bone, the distance between the two vertical portions of the palate bones, or width of the choanæ, and the relative heaviness of the zygoma. Each of these points will be considered in detail.

## POSTORBITAL PROCESSES

The postorbital processes are conspicuously developed in all of the Leporidæ. In general and typically the process is triradiate, one arm being attached to the skull and forming the pedicle of the process, the other two arms or angles being toward the outside, one directed anteriorly, the other posteriorly. The following seven forms of postorbital processes are found:

1. Postorbital processes large and triangular, standing out from the side of the head and considerably arched from before backward. This form is best developed in the subgenus *Lepus*, where the process is a conspicuous triangle, one angle of which is attached to the skull, the other two angles of which are entirely free, the anterior subtending a large anterior notch, and the posterior subtending a larger posterior notch. Occasionally in some specimens the anterior angle of the postorbital process is directed inward, its apex meets the frontal bone and a distinct foramen is formed instead of a notch. In the subgenus *Macrotolagus* the posterior angle of the postorbital process is always directed inward to meet the side of the cranium and in this way forms the outer boundary of a conspicuous foramen. Some of the Old World specimens resemble *Macrotolagus* in this respect; such are *Lepus* *sp.* Jumna river, India; *L. ochropus*, East Africa; *L. hypsibius*, Ladak, and *L. tibetanus*, central Asia. In the hares belonging to the subgenus *Pacilolagus* the postorbital processes, while of the same general form, are much slenderer, the outer angles are not so wide, and the process is not so arched as it is in its best developed form in the subgenus *Lepus*. Both anterior and posterior angles are free, and help to form corresponding notches with the rest of the skull. The posterior angle and notch are larger than the anterior angle and



SKULLS OF HARES (about  $\frac{1}{2}$  natural size). 1, 1a, subgenus *Macrotolagus*. 2, 2a, subgenus *Lepus*. For explanation see page 443.

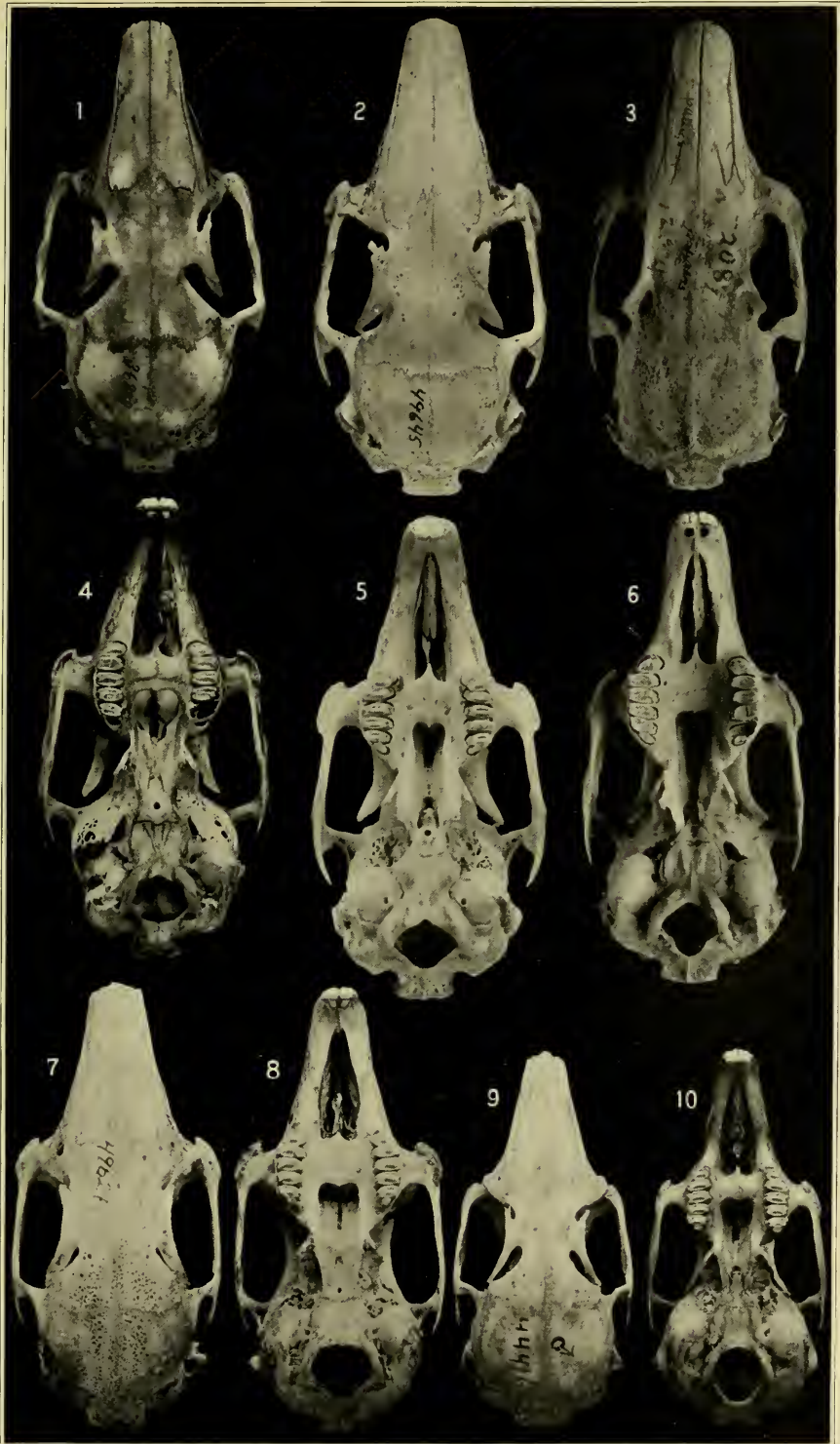






SKULLS OF HARES (about  $\frac{1}{2}$  natural size). 1. Subgenus *Pacitolagus*. 2. Subgenus *Macrotolagus*. 3. Subgenus *Lepus*. For explanation see page 443.



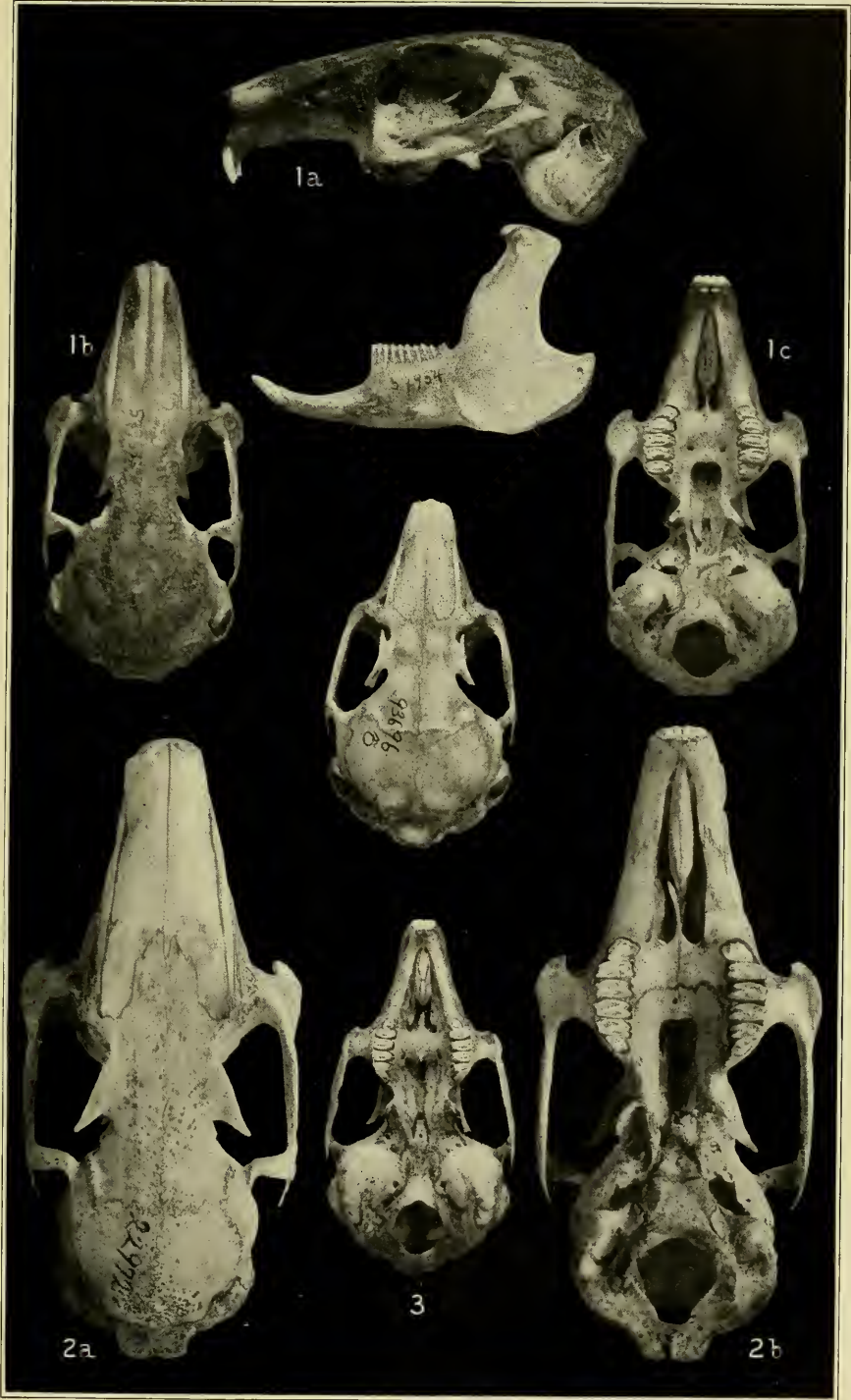
SKULLS OF HARES AND RABBITS (about  $\frac{2}{3}$  natural size). For explanation see page 43.





SKULLS OF RABBITS (about  $\frac{1}{2}$  natural size). For explanation see page 443.





SKULLS OF RABBITS (natural size). 1. *Romerolagus*. 2. *Pronolagus*. 3. *Brachylagus*.

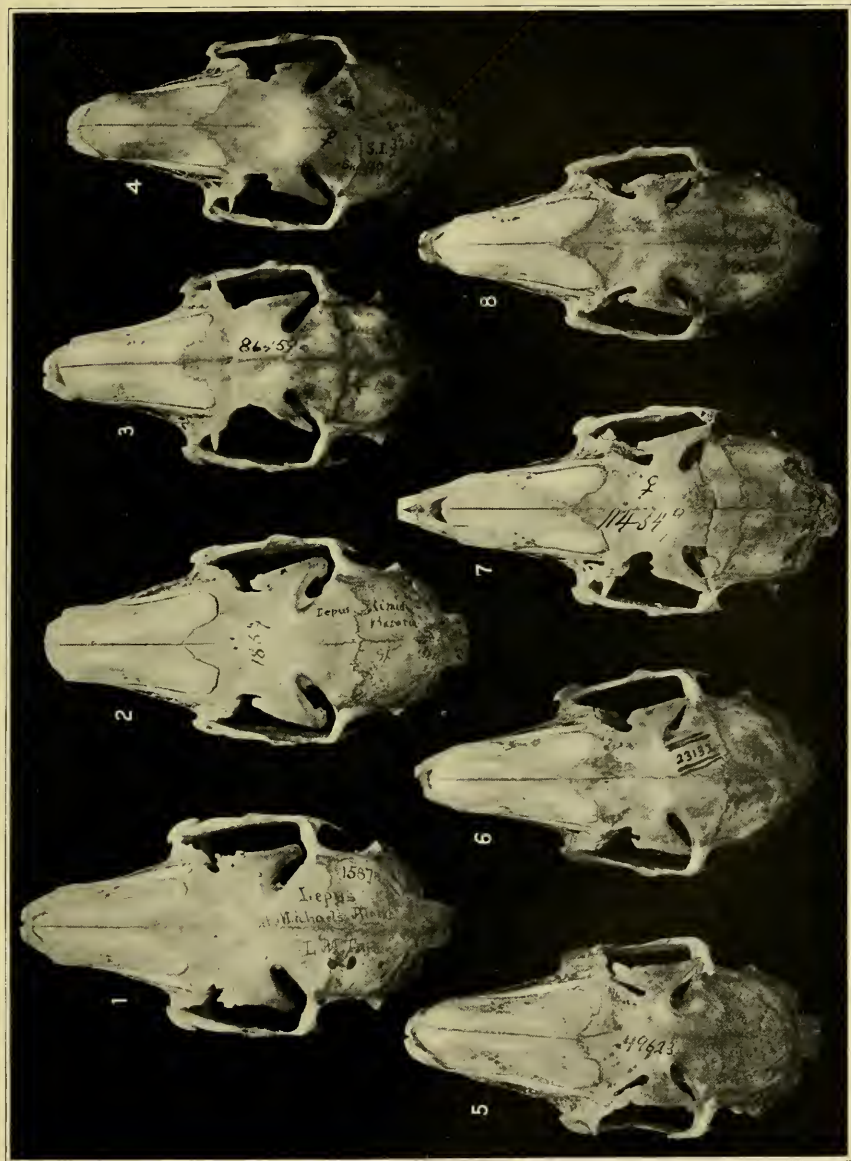






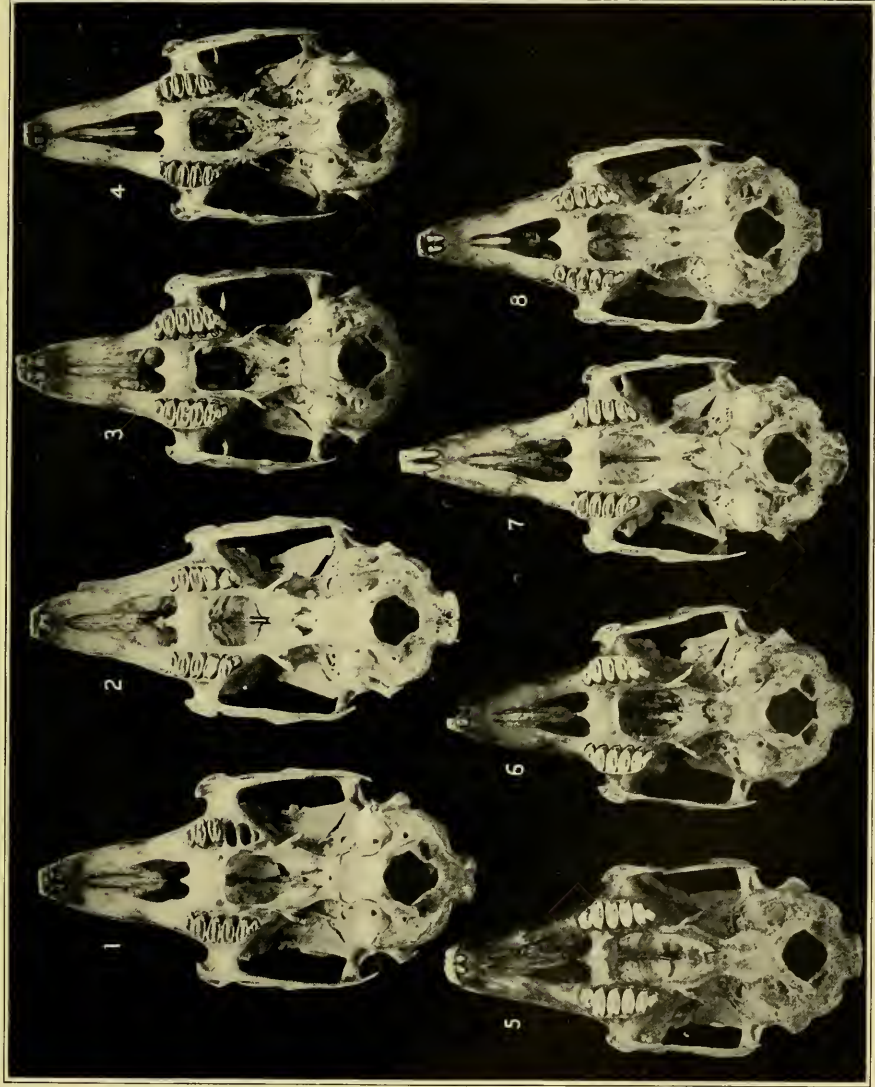
SKULLS OF RABBITS (natural size). 1, *Brachylagus*. 2a, 2b, 2c, *Pentalagus*.





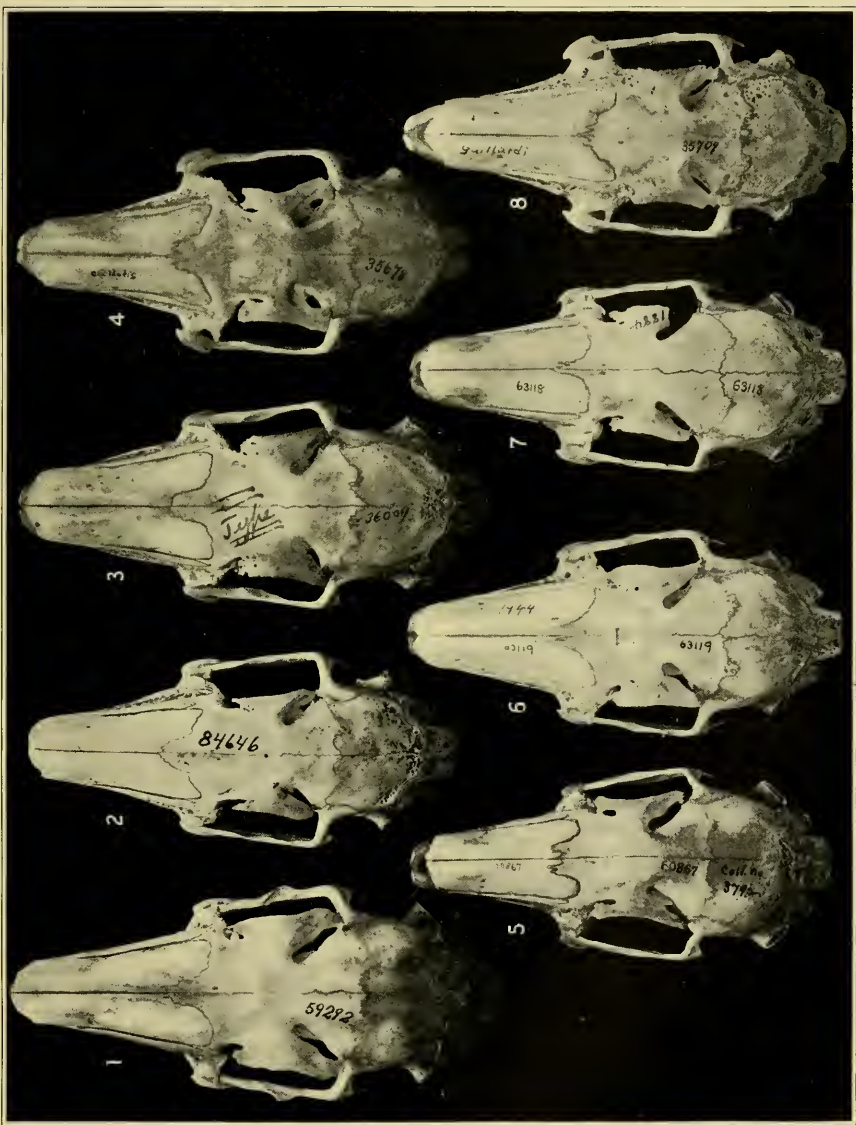
SKULLS OF HARES, subgenus *Lepus* (about  $\frac{2}{3}$  natural size). For explanation see page 444.





SKULLS OF HARES, subgenus *Lepus* (about  $\frac{2}{3}$  natural size). For explanation see page 444.

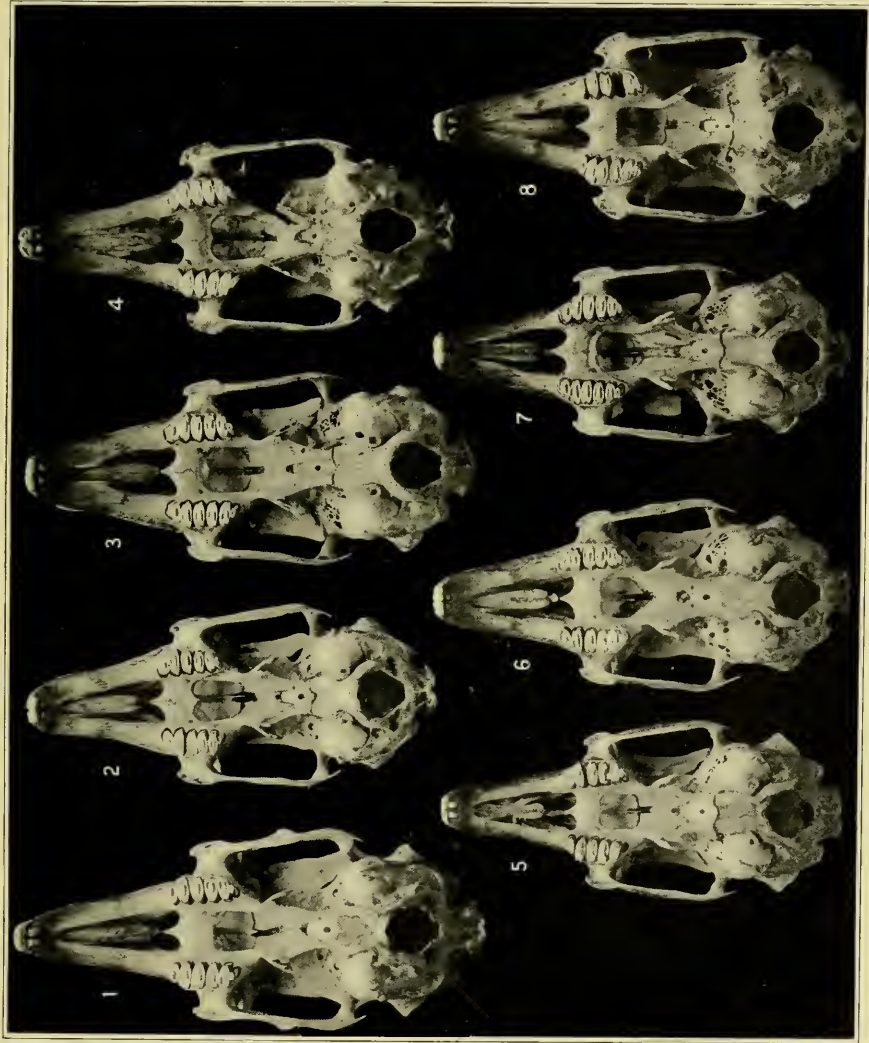




SKULLS OF JACKASS HARES, subgenus *Macrotlagus* (about  $\frac{2}{3}$  natural size). For explanation see page 444.

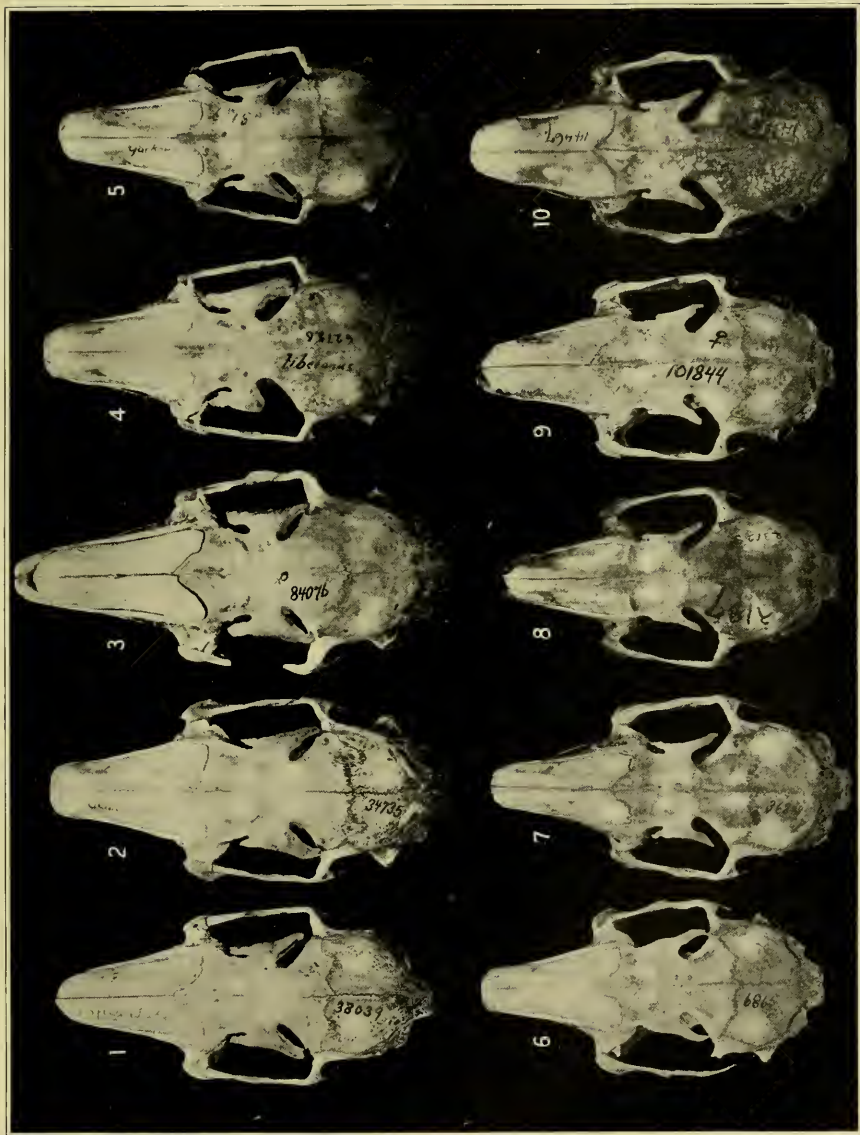






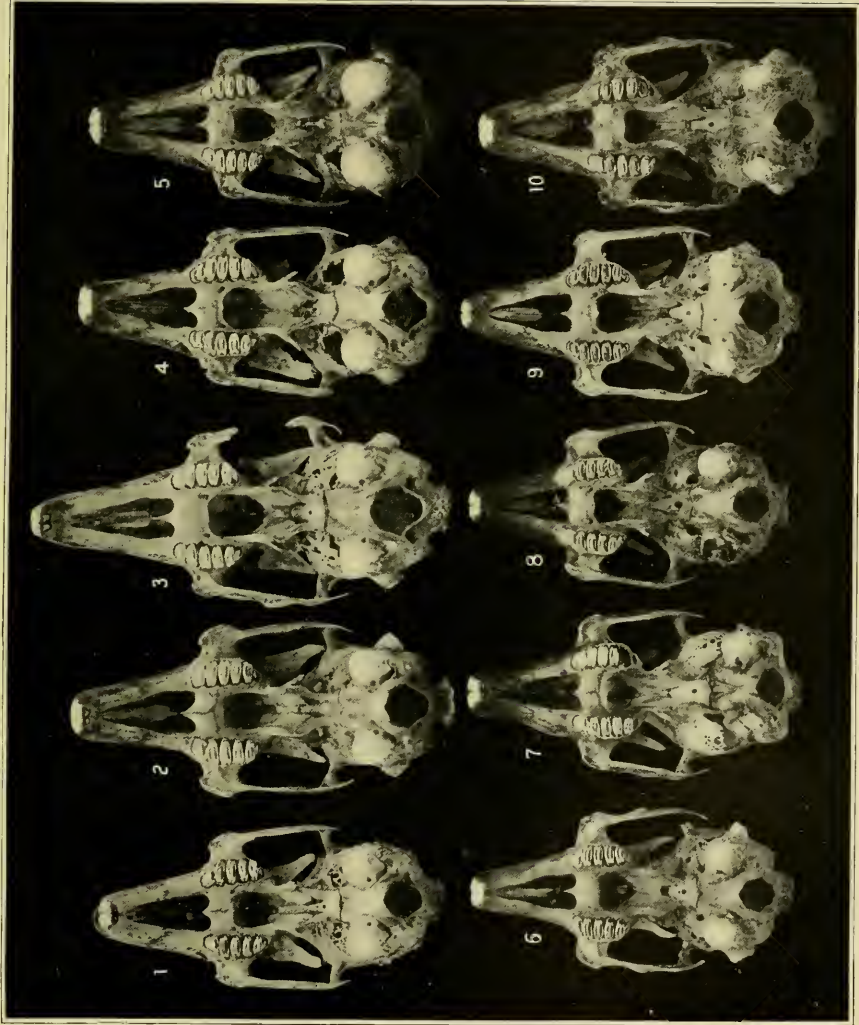
SKULLS OF JACKASS HARES, subgenus *Macrotlagus* (about  $\frac{2}{3}$  natural size). For explanation see page 444.





SKULLS OF HARES (about  $\frac{1}{2}$  natural size). For explanation see page 444.





SKULLS OF HARES (about  $\frac{2}{3}$  natural size). For explanation see page 444.

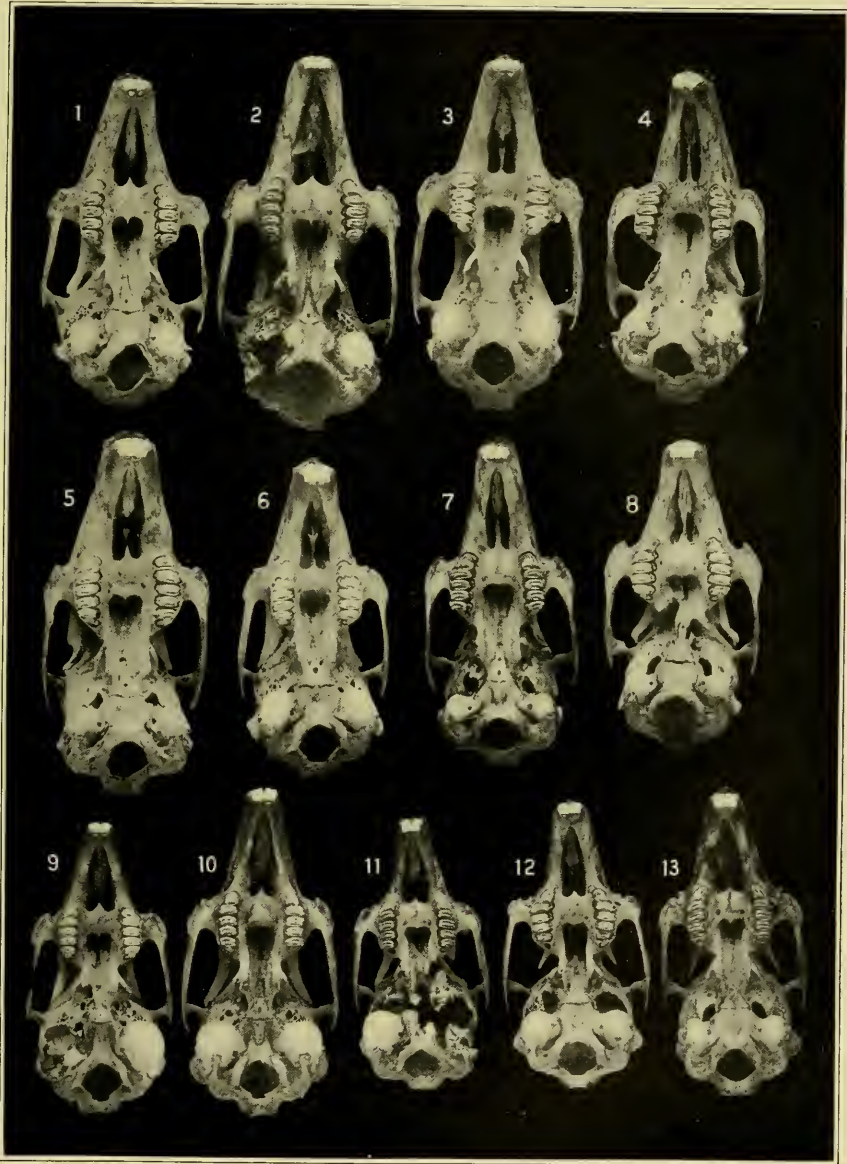




SKULLS OF COTTONTAILS, genus *Sylvilagus* (about  $\frac{1}{4}$  natural size). For explanation see pages 444, 445.

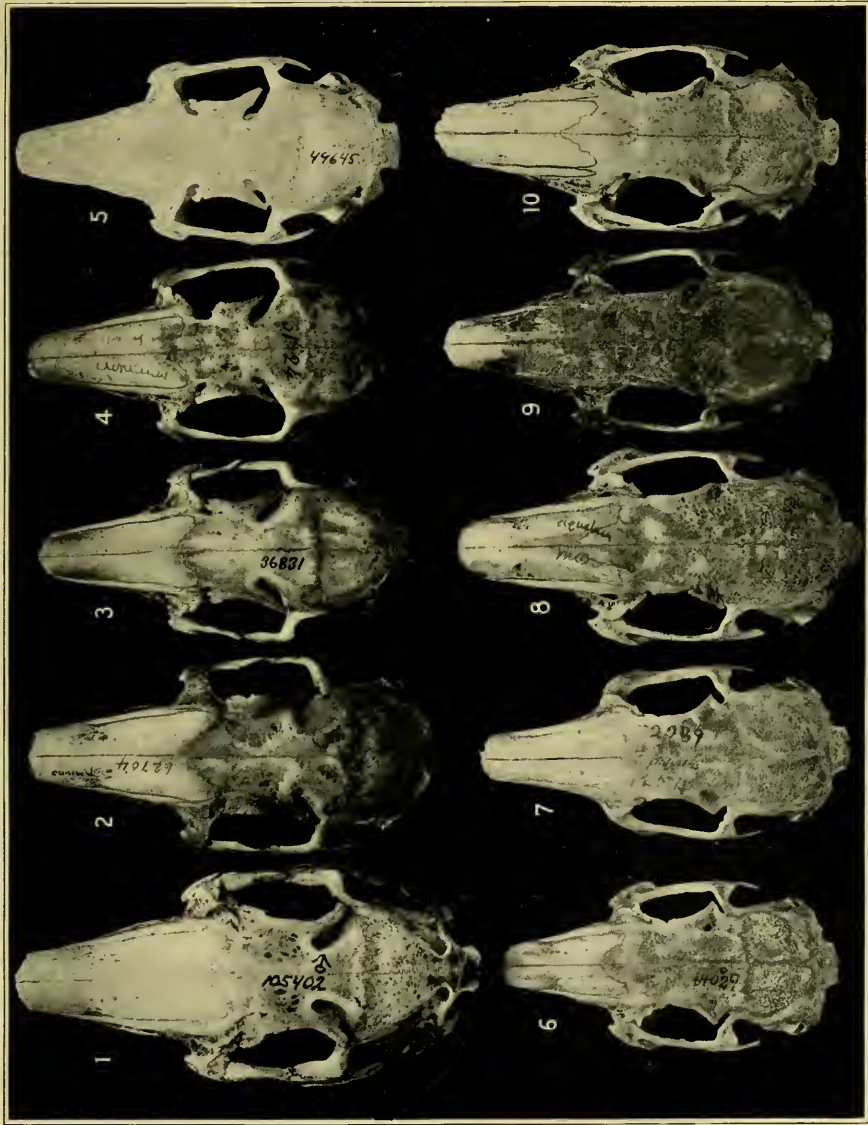






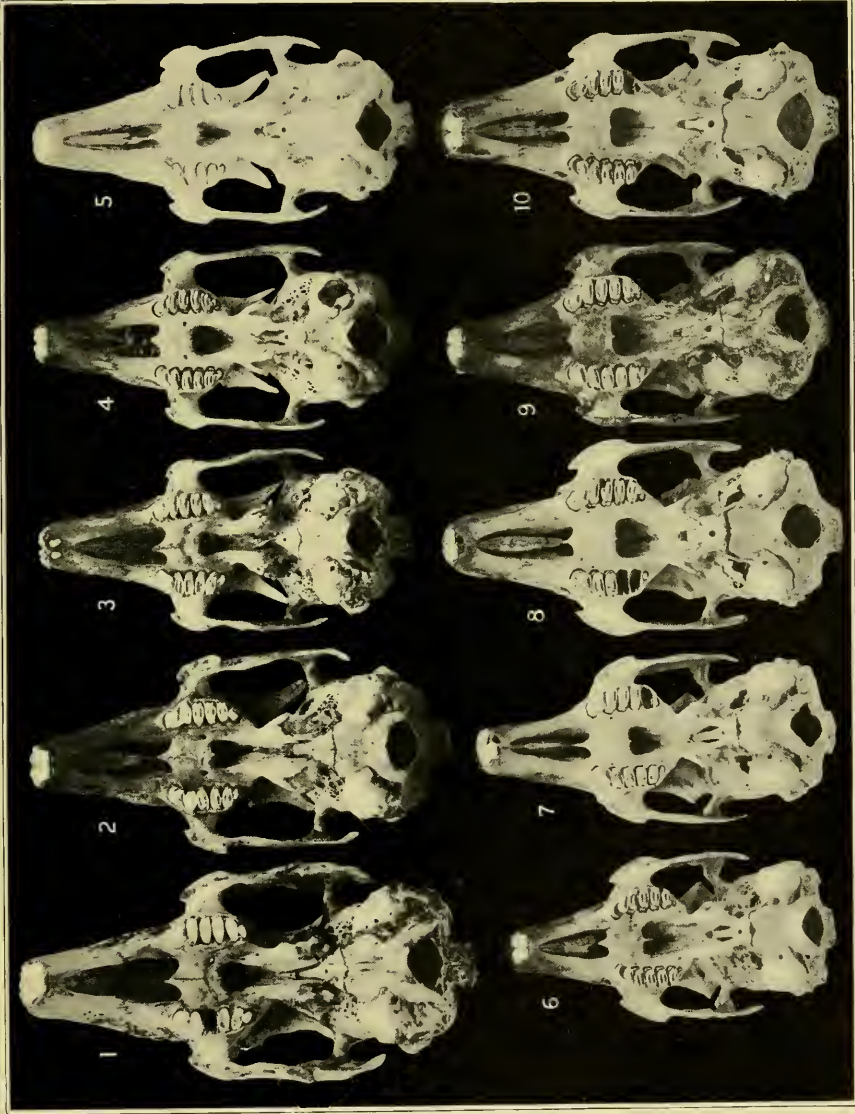
SKULLS OF COTTONTAILS, genus *Sylvilagus* (about  $\frac{1}{4}$  natural size). For explanation see pages 444, 445.





SKULLS OF EUROPEAN RABBITS, *Oryctolagus*, 1-5: SWAMP RABBITS, *Linnolagus*, 6-10 (about  $\frac{2}{3}$  natural size).





SKULLS OF EUROPEAN RABBITS, *Oryctolagus*, 1-5; SWAMP RABBITS, *Limnolagus*, 6-10 (about  $\frac{2}{3}$  natural size).



notch. *Lepus yarkandensis* from central Asia has postorbital processes agreeing with those of *Pacilolagus*.

2. The skulls having postorbital processes most nearly resembling those of typical *Lepus*, belong to the genus *Oryctolagus*. The processes are here large, but are not wide and triangular and they do not project out laterally from the sides of the skull as they do in *Lepus*. The process is arched. The anterior portion does not meet the frontal bone and thus subtends a notch, and a larger posterior notch is formed by the posterior angle which also does not meet the cranium. In two skulls of domestic rabbits at hand, a lop-eared and a Belgian hare, the anterior angle or limb of the postorbital process meets the frontal bone, and in the lop-eared forms the outer boundary of an irregular foramen, while in the Belgian hare the whole anterior angle is fused to the cranium, so that even the foramen is obliterated. In both these specimens posterior notches are present.

3. In the third form of postorbital process, the anterior limb is entirely lacking or else so intimately associated with the cranium that the process appears as a triangle, one whole side of which is attached to the cranium, the second side directed outward and somewhat forward, while the third side is directed obliquely inward and backward, forming the outer boundary of a posterior notch. This type of postorbital is found in the genera *Romerolagus*, *Pronolagus*, *Caprolagus*, *Pentalagus*, and probably in *Nesolagus*. The process is larger and blunter in *Pentalagus* than it is in the others.

4. Postorbital processes long and narrow, strongly arched, attached to the skull by a very broad and short pedicle. The whole anterior part of the process, with the exception of a millimeter or two, is attached to the skull, so that only a very small notch is subtended. The posterior part of the process is long and narrow, not triangular as it is in skulls of the preceding type. Its inner posterior edge touches the side of the cranium, and a narrow clavate slit is thus formed between the inner edge of the process and the side of the skull. In its typical form this slit or clavate foramen is much narrower than the process which helps to make it. In one skull of *Sylvilagus floridanus mearnsi*, No. 22,409, from Illinois, complete fusion of the postorbital process with the side of the skull takes place, and the clavate foramen is obliterated. The opposite extreme is found in the group of *Sylvilagus arizonæ* and its subspecies, where the clavate foramen is relatively wider and passes gradually over into the next style of postorbital. In these atypical forms the anterior notch is also relatively larger than it is in typical *Sylvilagus*.

5. In many respects the postorbital processes included in this division resemble the postorbital processes found in that section of the genus *Lepus* which forms the subgenus *Pæcilolagus*, but on the whole they are rather slenderer, and do not project so far outward from the side of the skull. The typical form is seen in *Sylvilagus (Microlagus) bachmani*. The postorbital process is attached by a comparatively narrow pedicle. A large posterior notch is formed between the sides of the skull and the slender posterior portion of the postorbital process. In No. 63,957, *Microlagus* from Posts, California, the posterior extremity of the postorbital almost touches the cranium. *Sylvilagus (Microlagus) cinerascens* shows conditions of the postorbital ranging all the way from those found in No. 63,957 to conditions almost identical with those found in typical *Sylvilagus*, but the posterior clavate foramen is always wider in *Microlagus*.

6. The postorbital processes of the skulls of the genus *Brachylagus* are small and slender, free both in front and behind. They bear considerable resemblance to the postorbitals of the subgenus *Pæcilolagus*.

7. The genus *Limnolagus* possesses postorbital processes of a form quite different from any of the others. The process is completely fused to the side of the frontal bone so that only a notch is found anteriorly and no notch or slit is found posteriorly except in rare and anomalous cases where a small foramen is sometimes seen. The fused postorbital process has about the same general shape as has the unfused process of the genus *Sylvilagus*. An atypical specimen, No. 64,029, Kissimmee, Florida, shows the manner in which the process is attached. The posterior end of the process, instead of meeting the skull directly as it does in those genera where the posterior end of the process is in contact with the side of the skull, is met by an outgrowing process from the cranium. In this specimen, No. 64,029, a small foramen is inclosed between the posterior part of the postorbital process and the above outgrowing process from the cranium. A more or less prominent blunt projection is formed by the union of the postorbital process with the outgrowing process from the cranium. This blunt projection above, together with the root of the zygomatic process just below, forms a rather conspicuous notch.

#### INTERPARIETAL BONE

The interparietal bone of the Leporidae is always present in the very young, and in most cases remains perfectly distinct in the adult.



On the other hand, in certain hares, the distinctness of the interparietal is lost at an early age, when the animal is but little more than half grown. Judging from rather limited material in cases where its distinctness is lost in the adults, it appears that the upper borders of the bone become obliterated, each half fusing with the parietal above, and the sagittal suture between the two parietals pushing down to meet the interparieto-supraoccipital suture. The distinctness or the obliteration of the interparietal is very constant, for the different groups of the Leporidae. It is found as an independent bone in *Sylvilagus*, *Brachylagus*, *Limnolagus*, *Oryctolagus*, *Romerolagus*. In the genus *Lepus*, the interparietal loses its distinctness before adult life is reached. In the single available skull of *Pronolagus* from South Africa, the inferior suture of the interparietal is distinct, as it always is; the right latero-superior suture is partially obliterated, and the left latero-superior suture is entirely obliterated. As the specimen is a young adult, it seems reasonable to say that the interparietal is obliterated in this case. In the genus *Pentalagus* the interparietal is not present as a distinct bone.

#### PALATE AND POSTERIOR NARES

The bony palate of all the Leporidae has its antero-posterior dimension very short, while the side-to-side dimension is considerable, so that the length of the bony palate is usually less than its width. The palatal portion of the bony palate is the part most reduced, and in some cases the horizontal plates of the palate bones form only the extreme posterior edge of the bony palate. The incisive foramina are very large, especially at the posterior ends, and extend from the anterior edge of the bony palate almost to the alveoli of the incisors. The roof of the nasal cavity is usually high, so that the sides of the posterior nares form a wall of considerable height, composed mostly of the vertical portion of each palate bone. All of these structures vary in several ways and constantly for certain groups.

*Variations in bony palate.*—In *Brachylagus* the bony palate is very short, shorter than in any other genus of the Leporidae. The horizontal plates of the palate bones form only the posterior border of it. In *Lepus* also the palate is short, but not so short as it is in *Brachylagus*. The horizontal plates of the palate bones form between a fourth and a third of the bony palate. Very similar to this arrangement is the bony palate of the genus *Sylvilagus*, which is typically a little longer than it is in *Lepus*, but in the rabbits of the *Sylvilagus arizonæ* group the bony palate has about the same relative

length that it has in *Lepus*. In *Sylvilagus* (*Microlagus*) *cinerascens* the bony palate is short, but in *S. (M.) bachmani* it is distinctly longer. In *Limnolagus* and *Oryctolagus* the bony palate lengthens, relatively speaking; the horizontal plate of the palate bone is better developed and enters into the formation of the bony palate to a slightly greater extent than in the case of the preceding genera, but to a less extent than it does in *Romerolagus*. The portion of the palate bone that borders the maxilla caudad of the posterior edge of the bony palate is better developed in *Limnolagus* and *Oryctolagus* than it is in *Lepus*, *Sylvilagus*, or *Brachylagus*, and thus forms part of the roof of the mouth along the posterior dental alveoli. This development of the palate bone just internal to the dental alveoli is better developed in *Oryctolagus* than in *Limnolagus*, and it is still further developed in the genera *Romerolagus* and *Pronolagus*. The last has the longest and narrowest bony palate of any of the Leporidae at hand, though *Romerolagus* has one nearly as long relatively. The horizontal plates of the palate bones in these two genera form about the posterior half of the bony palate. *Pentalagus* and *Nesolagus* have long palates resembling those of *Romerolagus* and *Pronolagus*, but the horizontal plates of the true palate bones form only the posterior fifth or fourth of the bony palate. The palate of *Caprolagus* is apparently similar, but the horizontal plates of the palate bones form its posterior third.

In most of the Leporidae the posterior palatine foramina are of moderate size and are located between the palatine plate of the maxilla and the horizontal plate of the palate bone, at the anterior outer angles of the horizontal plate. In *Romerolagus*, however, the posterior palatine foramina are relatively very large and in the usual position. In *Pronolagus* the posterior palatine foramina are very small, and are scarcely visible except for two grooves leading from them. They are situated not at the anterior outer angles of the horizontal plate of the palate bones, but are found near the median line, toward the anterior internal angles of the horizontal plates of the palate bones.

*Variations about the posterior nares or choanae, and width of the incisive foramina.*—Certain variations are found in the degree of approximation of the vertical plates of the palate bones, the height of the pharyngeal vault, and the width of the incisive foramina, and when compared with the length of the bony palate measured half-way between the median line and the dental alveoli, there are found ratios which are seen to be fairly constant for the different groups of the Leporidae.

Wide choanæ are found in *Lepus* and *Brachylagus*. They are remarkably wide when compared with the narrow choanæ of *Oryctolagus*. In both of the former the length of the bony palate, measured midway between the median line and the dental alveoli, is decidedly less than the least distance between the two vertical plates of the palate bones. In the same two genera the incisive foramina are wide, especially so in *Brachylagus*, where the greatest width of each incisive foramen nearly equals in length the bony palate measured midway between the median line and the dental alveoli. In *Lepus*, the greatest width of the incisive foramina taken together is much greater than the length of the bony palate.

The choanæ are wide in *Sylvilagus*, but not quite so wide as they are in *Lepus* and *Brachylagus*. In certain species of *Sylvilagus*, *arizonæ* and its allies, the lateral walls of the choanæ are more approximated than they usually are in most rabbits, and approach the narrow choanæ seen in *Oryctolagus*. The length of the bony palate taken midway between the median line and dental alveoli equals the greatest width of the incisive foramina as well as the distance between the choanal walls. In the *Sylvilagus arizonæ* group this palatal length is less than the width of the incisive foramina, but equals the distance between the choanal walls.

In *Limnolagus* the length of the palate taken between the median line and the dental alveoli about equals the greatest width of the incisive foramina taken together, and the distance between the vertical plates of the palate bones. The choanæ are narrower than they are in *Lepus*, but are not so extensively narrowed as they are in *Oryctolagus*.

The length of the relatively long bony palate of *Romerolagus* is very much greater than the greatest width of the two incisive foramina and also very much greater than the choanal width.

In the genus *Pronolagus* the incisive foramina are long and narrow, less triangular in outline than they are in most of the Leporidae. Their greatest width is much less than the length of the bony palate. The choanæ are rather narrowed, being almost as narrow as they are in *Oryctolagus*, but the pharyngeal vault is not so high as it is in the latter genus.

In the skull of *Caprolagus*, as figured by Blyth, the incisive foramina are narrow, elongated-triangular, the choanæ are moderately wide, about as wide as the greatest width of the narrow incisive foramina taken together. The bony palate is long, decidedly longer than the choanal width.

In *Pentalagus* the incisive foramina are narrow, their sides nearly

parallel. The choanæ are wide, much wider than the greatest width of the incisive foramina taken together. The bony palate is long, exceeding in length the rather wide choanæ. The pharyngeal vault is low.

In *Nesolagus* the incisive foramina are rather narrow, about as wide as they are in *Caprolagus*; but instead of being triangular, their sides are nearly parallel, in this respect resembling the incisive foramina of *Pentalagus* and *Pronolagus*. Their greatest width taken together is a little less than the choanal width and much less than the length of the bony palate.

In *Oryctolagus* the distance between the vertical plates of the palate bones is less in proportion to size than in any other member of the family Leporidae. The incisive foramina are narrow, their greatest width not quite equal to the length of the bony palate taken half-way between the median line and the dental alveoli, and much greater than the distance between the lateral choanal walls. The pharyngeal vault is high.

Following is a summary of the relative sizes of the greatest width of the incisive foramina, the length of the palate measured between the median line and the dental alveoli, and the distance between the two vertical portions of the palate bones:

In *Limnolagus* and typical *Sylvilagus* the width of the incisive foramina, the length of the palate, and the width of the choanæ all about equal one another.

In *Romerolagus* the width of the incisive foramina and the choanal widths are subequal to one another and each is less than the length of the palate.

In *Lepus* and *Brachylagus* the width of the incisive foramina and the width of the choanæ are much greater than the length of the palate.

In *Pentalagus* the width of the incisive foramina is less than half the length of the bony palate; the width of the choanæ is not much less than the length of the bony palate.

In *Oryctolagus* the width of the incisive foramina about equals the length of the palate, while the width of the choanæ is less than the palatal length.

In *Pronolagus* the width of the incisive foramina is a little less than the length of the palate; the width of the choanæ is less than the palate length.

In *Caprolagus* and *Nesolagus* the width of the incisive foramina taken together is less than the length of the palate, and the length of the palate is greater than the choanal width.

## ZYGOMATIC ARCH

The zygomatic arch of the Leporidae is well developed. Seen from above or below it is very narrow, and is much flattened when seen from the side. In the adult but two bones seem to make it up, viz., the zygomatic process from the squamosal, and what is apparently a very long backwardly projecting zygomatic process of the maxilla, but this latter consists of the true malar or jugal bone, which forms most of the zygoma and fuses at a very early age with a small zygomatic process of the maxilla. The zygomatic process of the squamosal is a triangular foot-like structure attached to the squamosal by a narrow pedicle. The squamoso-zygomatic suture remains distinct throughout old age. The malar projects caudad of the zygomatic process of the squamosal, to a greater or less extent. In the family Leporidae the antero-inferior angle of the zygoma is usually enlarged and flares outward to a greater or less extent.

The heaviest zygomata are seen in *Romerolagus* and *Limnolagus*, in each of which it is thick and deep, especially deep in *Romerolagus*. In *Lepus* and *Brachylagus* the zygoma is deep but not thickened. In *Oryctolagus* the anterior half of the zygoma is deep, but in the posterior half it is shallower. *Sylvilagus* and *Pronolagus* have zygomata that are rather thin and shallow when compared with the zygomata of the other genera.

The foot-like extremity of the zygomatic process of the squamosal is shorter in *Lepus* than it is in most of the other Leporidae. The external lateral length of the squamoso-malar suture is contained about two times in the superior border of the malar, measured from the anterior end of the squamoso-malar suture to the antero-inferior angle of the orbit. In *Oryctolagus*, *Pentalagus*, and *Caprolagus*, on the other hand, the foot-like extremity of the zygomatic process of the squamosal is considerably enlarged, so that the lateral length of the squamoso-malar suture is contained between one and one and a half times in the superior border of the malar, measured from the anterior end of the squamoso-malar suture to the antero-inferior angle of the orbit. In *Romerolagus* the foot-like extremity of the zygomatic process of the squamosal is moderately enlarged; in *Brachylagus* it is relatively slightly larger than it is in *Lepus*. In *Sylvilagus* and *Pronolagus* the size of the foot-like extremity of the zygomatic process of the squamosal has about the same relation to the rest of the zygoma that it has in *Lepus*. In *Limnolagus*, the foot-like extremity of the zygomatic process of the squamosal is short.

The antero-inferior end of the zygoma is much expanded and flared outward in *Limnolagus*, *Nesolagus*, and *Romerolagus*. It is also enlarged, but not quite to the same degree in *Oryctolagus*. In *Pronolagus* it is moderately enlarged. In *Lepus*, *Sylvilagus*, *Brachylagus*, and *Pentalagus* the antero-inferior angle of the zygoma is only slightly enlarged. In the last the deep fossa seen just in front of the antero-inferior angle of the zygoma in the other genera except *Limnolagus* is lacking. In *Caprolagus* the antero-inferior angle of the zygoma is apparently not enlarged at all.

The posterior free projecting extremity of the malar is very large and long in *Romerolagus*, and is nearly as large in *Limnolagus*, *Oryctolagus*, and *Caprolagus*. It is moderately enlarged in *Pentalagus* and in *Brachylagus*; in the remaining genera, *Lepus*, *Sylvilagus*, and *Pronolagus* the posterior free extremity of the malar is short.

#### AUDITAL BULLÆ

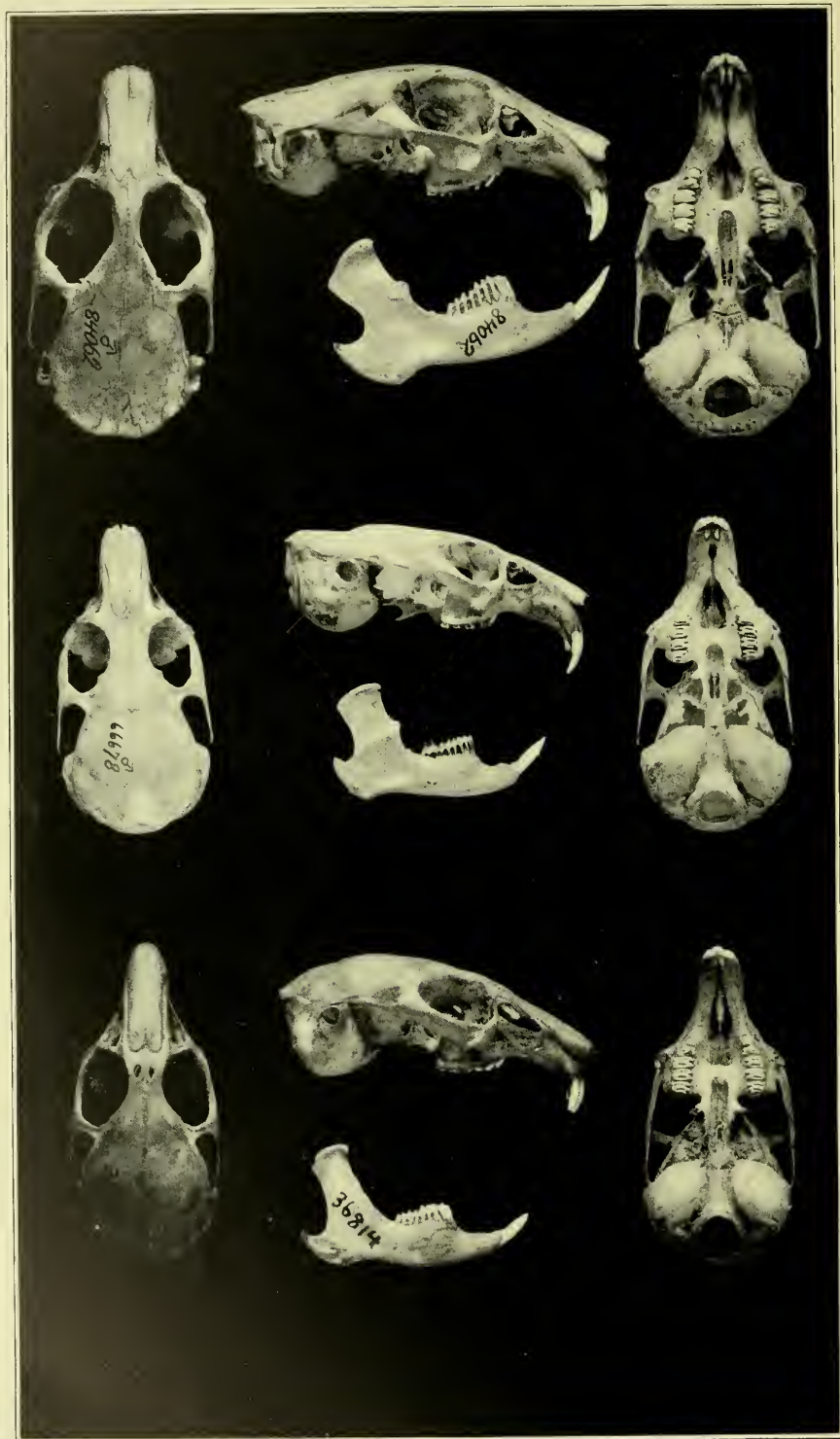
Most of the Leporidae have well-developed audital bullae, but the degree of development is subject to some variations. The external auditory meatus is prolonged upward and backward into a tubular or spout-like structure. The bulla and this tube combined much resemble a flask, the external auditory meatus being the neck.

In *Brachylagus* the audital bulla is very much enlarged, the external auditory meatus large and rounded. *Pronolagus*, *Caprolagus*, and *Pentalagus* have very small audital bullae. The external auditory meatus in the last is not at all spout-like; it has the form of an irregular oval bony ring, rather closely applied to the side of the skull. *Romerolagus* has the external auditory meatus relatively larger than in any of the other genera, and decidedly oval in outline, instead of simply circular. The rest of the Leporidae present nothing unusual in respect to the audital bullae or the external meatus.

#### FENESTRATION OF MAXILLÆ

The sides of the maxilla are fenestrated in nearly all the Leporidae. In certain groups, however, this fenestration is less marked than in others. In *Pentalagus* there is practically none. In *Limnolagus*, *Pronolagus*, and *Romerolagus* the degree of fenestration is much less than it is in all the other genera, which may be said to have a normal degree of fenestration. In the genera with the least degree of fenestration, the infraorbital foramen is most marked and attains its largest size.





SKULLS OF PIKAS, *Ochetona* (natural size). Subgenera: *Ochetona* 84,062, *Pika* 66,678, *Conothoa* 36,814.



## MANDIBLE

The mandible of the Leporidae is characterized by the great development of the angular process and of the condyloid process and by the almost complete absence of the coronoid process. It does not show very many variations, but there are a few which are constant for some of the genera.

In *Lepus* and *Oryctolagus* the mandibles resemble one another closely, and may be said to possess the typical form.

In *Pronolagus* the angular process of the mandible is rather straighter along the lower edge than it is in the mandible of the *Lepus* type. The mandible of *Caprolagus* apparently resembles it.

The mandible in *Limnolagus* has a very large, rounded, angular process. The ascending ramus is rather wider than it is in the genus *Lepus*. The notch between the condyle and the angular process is much smaller than it is in *Lepus*. The condyle has a greater antero-posterior dimension.

The mandible of *Nesolagus* is similar, but the angular process is smaller.

The mandible of *Sylvilagus* very closely resembles that of *Lepus*, but the angular process is relatively larger, and the notch between the condyle and the angular process is shorter. In this respect it resembles the mandible of *Limnolagus*.

*Brachylagus* has a mandible resembling a small one of the *Lepus* style, but the angular process is relatively as well as absolutely smaller, and its edge is nearly straight.

The mandible of *Romerolagus* possesses wide ascending rami, which are nearly vertical. The angle is well developed and its edge moderately rounded. The notch between the ascending ramus and the angular process is larger than it is in any of the other genera.

The mandible of *Pentalagus* has a very large, rounded, angular process, which is separated from the condyle by a small, shallow notch. The antero-posterior dimension of the ascending ramus and of the condyle is much greater relatively than it is in the other Leporidae. It is an exaggeration of the mandible of *Limnolagus*.

## OCHOTONIDÆ

(PLATE XC)

The skull in the Ochotonidæ is so entirely different in form and structure from that of the Leporidae, that it is almost superfluous to point out differences. The most conspicuous points in the skulls of the Ochotonidæ that serve to separate them from the Leporidae

are, the absence of postorbital processes, the general flatness of the brain-case, the much greater development of the posterior free extremity of the malar, the shortness and slenderness of the rostrum, the greater interorbital construction, and the differences in the shape of the palate, all of which are best seen in the figures. The fenestration of the maxillary bone in the Leporidæ is replaced in the Ochotonidæ by a single large opening in the side of the bone.

The mandible of the Ochotonidæ, although presenting many differences from that of the Leporidæ, is built on the same general plan. In *Ochotona* the ascending ramus is relatively much wider. The groove on the anterior surface of the ramus and the thin plate of bone forming the outer border of this groove in the hares is not found in the pikas. Just below the middle of the anterior surface of the ascending ramus of the mandible of *Ochotona* is a more or less prominent tubercle that is lacking in *Lepus* and its allies.

Corresponding to the shorter rostrum of the pikas, that portion of the mandible between the series of grinding teeth and the incisors is relatively shorter than it is in the hares.

The mental foramen in the Leporidæ is situated on the side of the mandible just anterior to the insertion of the first cheek tooth; in the Ochotonidæ the mental foramen is located on the side of the mandible situated as far posteriorly as the last lower molar. The few skulls of the genus *Ochotona* that are available for study show striking differences among themselves and may be placed in three groups, which will be described further on as subgenera.

The brain-case is generally flat and not rounded in *Ochotona*, especially so in the North American species, where the whole skull is also flat. In the group represented by *Ochotona ladacensis* the skull as a whole is not flattened, although the brain-case is; the interorbital region is much constricted and highly arched. In the group containing *Ochotona roylli*, the brain-case is less flattened than in the other and more typical forms; it is somewhat rounded, suggesting the brain-case of the Leporidæ.

Two general styles of incisive foramina are found in the Ochotonidæ: (a) incisive foramina resembling those of the Leporidæ in general shape, but at the same time encroaching much farther back on the bony palate, represented by *Ochotona roylli*; (b) incisive foramina constricted into two unequal portions by the approximation, if not actual union, in the median line, of the posterior ventral portions of the premaxillæ, the anterior portions of the foramina being very small, and the posterior portions very large

and wide, represented by the American species and *Ochotona ladacensis*.

In the *Ochotona royllii* group all the available skulls have an oval foramen between one and two millimeters in length in the anterior and superior part of each frontal bone. This foramen is not seen in any of the other skulls, although some of the American specimens, notably 36298, *O. collaris*, Fort Yukon, Alaska, show light spots in the anterior part of the frontal bone, evidently the equivalent of the two above mentioned foramina.

In *Ochotona royllii* the single large opening in the side of the maxilla is less rotund than in the other species at hand, is more elongated, and immediately beneath it there is a small amount of fenestration.

## TEETH

### LEPORIDÆ

(PLATE XCI, 2-9)

The dental formula of most of the Leporidæ is  $I \frac{2}{1}$ ,  $C \frac{0}{0}$ ,  $Pm \frac{3}{2}$ ,  $M \frac{3}{3}$ . In the genus *Pentalagus* the molars are reduced to  $\frac{2}{3}$ . As there are no differences in structure between some of the premolar and the molar teeth, in what follows in regard to the teeth, the premolars and molars taken together will be called the molariform teeth.

*Incisors*.—The first upper incisors are large and heavy, being typical rodent incisors in general form. The second upper incisors are minute teeth placed directly behind the first incisors. The anterior surface of each front incisor is marked by a longitudinal groove, extending more or less deeply into the tooth, and which may or may not be filled with cement.

The lower incisors are perfectly plain rodent incisors.

*Check Teeth*.—All the upper molariform teeth are built on the plan of a cylinder, filled up with cement and dentine. The cylinder, however, is not circular in section, and the enamel undergoes certain infoldings, except in the last tooth of the series. The greatest diameter of each tooth is from side to side.

The first upper molariform tooth has enamel variously infolded on its anterior face; most commonly there is a deep median reentrant angle, and two smaller reentrant angles, one on each side of the median one. On the other three faces of the tooth the enamel is not infolded.

The second, third, fourth, and fifth upper molariform teeth have each a single deep reentrant angle on the inner side, the sides of

which angle are more or less crenated. The enamel is well marked in this loop and on the anterior and posterior faces of the teeth, but it is scarcely discernible on the outer sides.

The last upper molariform tooth is very small, subterete, and without reentrant angles.

The lower molariform teeth, while built essentially on the same plan as the upper molariform teeth, are more difficult to understand, owing to the greater extent of the infolding of enamel which takes place in all the teeth, even the last small tooth. The infolding of the enamel is on the outer side of these teeth, and not the inner side, as in the case of the upper molariform teeth.

The first lower molariform tooth is divided into an anterior and a posterior portion in most Leporidae by a single deep reentrant angle extending across the tooth from the external face. In three genera, however, *Romerolagus*, *Pronolagus*, and *Pentalagus* (and perhaps *Nesolagus*), this tooth is divided into anterior and posterior portions by two reentrant angles, each extending half-way across the tooth, one from the external face and one from the internal. The anterior portion of this tooth has various minor reentrant angles on the anterior or lateral surfaces, or on both. Each of the second, third, and fourth lower molariform teeth appears like a double tooth of two compressed parts, of which the more anterior is the larger and stands higher up.

The last lower molariform tooth is much reduced in size, but similar to the others in structure, with a larger elliptic anterior portion and a smaller rotund posterior portion.

Following are the tooth variations in different genera of the Leporidae:

*Incisors*.—The groove on the anterior surface of the first upper incisor is shallow and is not filled with cement in *Pacilolagus*, *Oryctolagus*, *Brachylagus*, *Pentalagus*, nearly all the members of *Sylvilagus* (where, however, the groove is deep and in some Mexican specimens it is filled with cement), *Romerolagus* (where the groove is still deeper), and *Pronolagus*. *Lepus* (*Macrotolagus*) *californicus* has a shallow unfilled groove. Most members of the subgenus *Lepus* have deep grooves, usually without cement.

The groove is shallow and filled with cement in *Limnolagus* and in *Lepus tibetanus*.

The groove is rather deep but simple and filled with cement in *Lepus* (*Lepus*) *campestris*, in *Lepus yarkandensis*, in *Lepus ochropus*, in *Lepus* (*Macrotolagus*) *texianus*, and in *Caprolagus*.



FIG. 44.—Enamel pattern of first right upper incisor of Hares, Rabbits, and Pikas, enlarged nearly four times. 1, *Brachylagus idahoensis*, No. 93696, Ione valley, Idaho. 2, *Sylvilagus (Microlagus) bachmani*, No. 98466, Bridgeville, California. 3, *Sylvilagus (Sylvilagus) floridanus*, No. 49586, Florida. 4, *Limnolagus paludicola*, No. 64029, Kissimmee, Florida. 5, *Romerolagus nelsoni*, No. 57954, Mt. Popocatepetl, Mexico. 6, *Lepus tibetanus*, No. 62126, Ladak. 7, *Lepus ochropus*, No. 34735, Kilima-njaro, Africa. 8, *Lepus yarkandensis*, No. 62132, eastern Turkestan. 9, *Lepus ruficaudatus*, No. 38039, India. 10, *Lepus* sp., No. 49621, Jumna river, India. 11, *Lepus (Macrotolagus) alleni*, No. 59292, Sonoyta, Mexico. 12, *Lepus (Macrotolagus) merriami*, No. 84643, Fort Clark, Texas. 13, *Lepus (Macrotolagus) gaillardi*, No. 35709, Chihuahua, Mexico. 14, *Lepus (Macrotolagus) asellus*, No. 36009, San Luis Potosi, Mexico. 15, *Lepus (Macrotolagus) callotis*, No. 8982, Chihuitan, Mexico. 16, *Lepus (Macrotolagus) texianus*, No. 63118, northeastern Mexico. 17, *Lepus (Macrotolagus) californicus*, No. 60867, southern California. 18, *Lepus (Pacilolagus) americanus*, No. 4325, Fort Liard, British America. 19, *Lepus (Lepus) campestris*, No. 61367, Madison, Minnesota. 20, *Lepus (Lepus) timidus*, No. 37137, Sweden. 21, *Lepus (Lepus) europaeus*, No. 105828, Switzerland. 22, *Oryctolagus cuniculus*, No. 3124, England. 23, *Pronolagus crassicaudatus*, No. 22972, South Africa. 24, *Pentalagus furnessi*, No. 5583, Liu Kiu islands. 25, *Ochotona ladacensis*, No. 84062, Ladak.

The groove is bifurcated internally, deep and filled with cement in *Lepus* (*Macrotolagus*) *gaillardi*, in *Lepus* (*Macrotolagus*) *alleni*, in *Lepus* (*Macrotolagus*) *merriami*, in *Lepus ruficaudatus*, in *Lepus* *sp.* from Jumna river, India. The groove is deep, filled with cement, and trifurcated in *Lepus* (*Macrotolagus*) *callotis* and *Lepus* (*Macrotolagus*) *asellus*.

It is rather difficult to make any general statement about the character of the groove, so far as groups go. In certain members of the genus *Lepus* this groove attains the greatest development, but at the same time in the subgenus *Pacilolagus* the groove is shallower than in any of the specimens at hand, and is not filled with cement. Even in the subgenus *Macrotolagus* the same extremes are met.

*Check Teeth.*—In *Brachylagus* the anterior surface of the first upper molariform tooth presents a single shallow reentrant angle. In all the other genera the anterior surface of the tooth presents a relatively deep median reentrant angle, and two shallower lateral reentrant angles, one on each side of the main median one. There is more or less individual variation in the depth and form of these folds, and occasionally the median fold itself is slightly crenated. In the genera *Pronolagus*, *Caprolagus*, and *Pentalagus* these reentrant angles are deeper than they are in any of the other genera. In *Pentalagus* the main reentrant angle of this tooth is much crenated.

The first lower molariform tooth has the simplest folding of enamel in *Brachylagus*, there being only a shallow reentrant angle on the outer surface of the anterior half.

The genera *Lepus*, *Oryctolagus*, and *Sylvilagus* all have a small reentrant angle on the anterior face of the first lower molariform tooth, and a broader one on the anterior half of the external surface. Some skulls of *Sylvilagus* from Mexico show two reentrant angles on the anterior surface, resembling *Limnolagus* in this respect.

In *Limnolagus* are found two or more reentrant angles which may be somewhat crenate on the anterior surface, and a broad crenated, reentrant angle on the anterior half of the external surface of the tooth. The whole anterior half of the tooth is more solid looking and more quadrilateral than it is in the other genera.

There are two deep simple reentrant angles in front on the first lower molariform tooth of *Pronolagus* and a broad shallow one on the external surface of the anterior half of the tooth. Unlike any other genus except *Romerolagus* and *Pentalagus*, *Pronolagus* has a deep reentrant angle on the internal face of the first lower molari-

form tooth, which, extending to the middle of the tooth and meeting the reentrant angle from the external surface, divides the tooth into an anterior and a posterior portion.

In *Romerolagus* there is a broad shallow infold of the enamel on the external surface of the anterior half of this tooth, but the anterior and internal surfaces of this part of the tooth are smooth. The main infold as in *Pronolagus* extends but half-way across the tooth, while a corresponding reentrant angle comes in from the internal surface, both angles contributing to the division of the tooth into an anterior and a posterior portion.

In *Pentalagus* the first lower molariform tooth is very long. It is divided by two well-marked reentrant angles, one from the internal and one from the external face, into two portions, a narrower longer anterior portion, and a broader shallower posterior portion. The anterior portion of this tooth has two reentrant angles on its anterior face, and one each on the internal and external faces.

In *Caprolagus* the anterior portion of the first lower molariform tooth is separated from the posterior portion by a single reentrant angle from the external surface. The anterior portion considerably exceeds in size the posterior portion; it has two narrow reentrant angles on its anterior face, a broad shallow one on the external face, and a similar one on the internal face. (Major '99, pl. 37, fig. 23.)

The reentrant angle of the second, third, fourth, and fifth upper molariform teeth of *Brachylagus* extends but half-way across the tooth; it is not crenated.

The second upper molariform tooth of *Nesolagus* has a short non-crenated reentrant angle extending about a third the distance across the tooth (Major '99, pl. 37, fig. 17). Probably the third, fourth, and fifth upper molariform teeth are similar.

In *Pronolagus* the reentrant angle of the second, third, fourth, and fifth upper molariform teeth extends nearly all the way across the tooth and is crenated. The internal half of the angle is rather wide and open.

In *Pentalagus* the reentrant angle of the second, third, fourth, and fifth upper molariform teeth extends completely across the tooth. The crenation of its sides is more marked than it is in any other genus of Leporidae. The sides of the angle are almost in contact throughout their entire extent.

In *Romerolagus* the crenated reentrant angle of the second, third, fourth, and fifth upper molariform teeth does not extend quite so far across the tooth as it does in *Pronolagus*, but at the same

time farther than it does in the remaining genera. The internal third of the reentrant angle is rather wide, as it is in *Pronolagus*.

In the remaining genera, *Lepus*, *Oryctolagus*, *Sylvilagus*, and *Limnolagus*, the reentrant angle of the second, third, fourth, and fifth upper molariform teeth is crenated and extends about three-quarters of the distance across the tooth. In *Limnolagus* the internal fourth of the fold is rather wide, resembling the condition seen in *Romerolagus* and in *Pronolagus*. In *Lepus*, *Oryctolagus*, and *Sylvilagus* the sides of the reentrant angles are almost in contact with one another throughout their whole extent.

In the second, third, and fourth lower molariform teeth of *Brachylagus* the single external reentrant angle divides the tooth into the usual anterior and posterior portions, but the latter portion has only about half the side-to-side diameter that the anterior portion has.

In *Pronolagus*, *Romerolagus*, and *Pentalagus* the posterior portions of the second, third, and fourth lower molariform teeth have lateral diameters equaling those of the anterior portions, but in *Pentalagus* the fold of enamel dividing these teeth into anterior and posterior portions is very deeply convoluted, very much more than it is in any other genus of the Leporidae.

In *Lepus*, *Oryctolagus*, *Sylvilagus*, *Limnolagus*, and *Caprolagus* the lateral diameters of the posterior portions of the second, third, and fourth lower molariform teeth are about four-fifths the lateral diameters of the anterior portions.

In all the genera the third upper molar is much reduced in size and is elliptic in section, and in *Pentalagus* it is not found at all. It is larger in *Pronolagus*, however, and is somewhat diamond-shaped. In *Caprolagus* it is relatively much smaller than it is in the rest of the Leporidae.

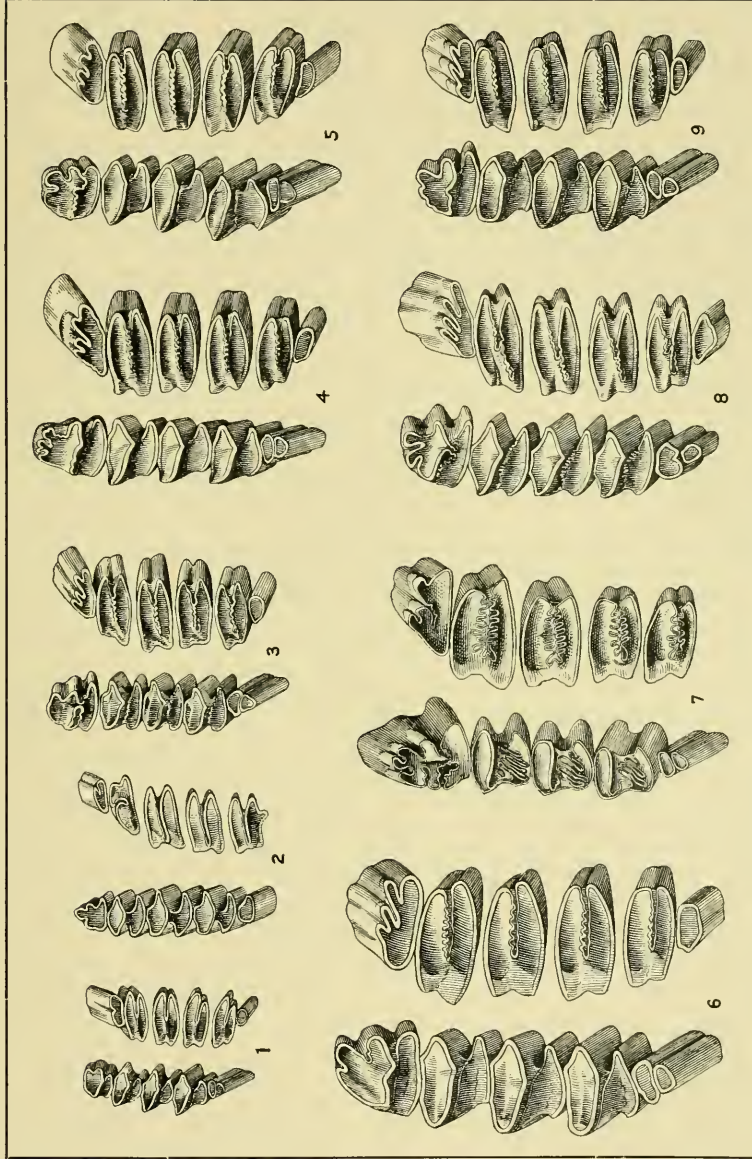
The last lower molar has the appearance of a double cylinder in all the genera, the anterior portion of which is larger and more elliptical in section, the posterior portion smaller and more terete. In *Pronolagus*, the reentrant angle, which divides this tooth into the two mentioned portions, is more marked than it is in the other genera, and the posterior face of the anterior cylinder is slightly indented.

#### OCHOTONIDÆ

(PLATE XCI, 1)

The dental formula of the Ochotonidæ is  $I \frac{2}{1}$ ,  $C \frac{0}{0}$ ,  $Pm. \frac{3}{2}$ ,  $M \frac{3}{3}$ , being the same as that of the Leporidae with the exception of the small last upper molar, which has been so reduced in *Ochotona* as to have disappeared, as is also the case with *Pentalagus* of the





TEETH OF HARES, RABBITS AND PIKAS (enlarged three times). For explanation see page 445.



Leporidæ. This is Forsyth Major's view on the relative number of premolars and molars in *Ochotona*. No. 84,064, *O. ladacensis* from Ladak, a young individual bears out this view, for it shows the third maxillary tooth in process of replacement by the permanent premolar.

The teeth of *Ochotona* are simpler in every way than the teeth of *Lepus* and its allies; they lack the more complicated infolding of enamel and its beautiful crenation.

*Incisors*.—The first upper incisors of the Ochotonidæ have each a simple groove. Their cutting edge is very sharp; the portion external to the groove much produced downward, the internal portions slightly so produced. In this manner an unequally sided V-like notch is seen on the front cutting edge of each tooth, with the groove at the point of the V.

The second upper incisors are small slender teeth placed behind the first pair as in the case of the Leporidæ.

The single pair of lower incisors of the Ochotonidæ are longer, slenderer, and more pointed than the corresponding teeth in the Leporidæ.

*Check Teeth*.—The first upper premolar is relatively much smaller than the corresponding tooth in the Leporidæ. It has a single reentrant angle, on its anterior face toward the inner edge.

The second upper premolar has a reentrant angle on its anterior face, extending to the middle of the tooth, and thence toward the outer edge. There is also a broad shallow angle on the internal face of this tooth.

The third, fourth, and fifth upper cheek teeth possess each a single reentrant angle on the internal face, extending all the distance across the tooth, very much like the reentrant angles of the Leporidæ, but lacking the crenation usually seen in that family. The last of these teeth has a projecting loop of enamel from the posterior aspect of the tooth, thus differing from the others.

The first lower premolar much resembles the anterior half of the first lower premolar of *Lepus*. It has two reentrant angles on the external face, and one on the internal.

The second, third, and fourth mandibular cheek teeth in *Ochotona* are much like the corresponding teeth of the Leporidæ, but the division into anterior and posterior portions is more marked, and the two portions are subequal.

The last lower molar is small, irregularly ovate in section, its pointed end being toward the external side. A posterior portion to this tooth is completely lacking.

## VERTEBRAL COLUMN

## LEPORIDÆ

The vertebral column in the different members of the Leporidæ, while of the same general type throughout, presents several peculiarities, constant for the various genera. The vertebral column in the Ochotonidæ, on the other hand, is different in many ways from that of the Leporidæ, as will be detailed below. The different sections of the vertebral column will be taken up successively, beginning with a general account of the structures of each series, followed by a discussion of the variations each series presents in the various genera.

*Cervical Vertebrae* (pl. XCII, 2-10).—The first cervical or atlas is large, with conspicuous wing-like transverse processes.

The second cervical or axis has a well-developed cylindrical odontoid process. Its centrum is long, its neural spine well developed, the antero-posterior length of the neural spine being greater than the corresponding length of the centrum. Transverse processes are present as caudad projecting spines on each side.

The third, fourth, and fifth cervical vertebrae have practically no neural spines; on the sixth there is a small neural spine and on the seventh a larger one.

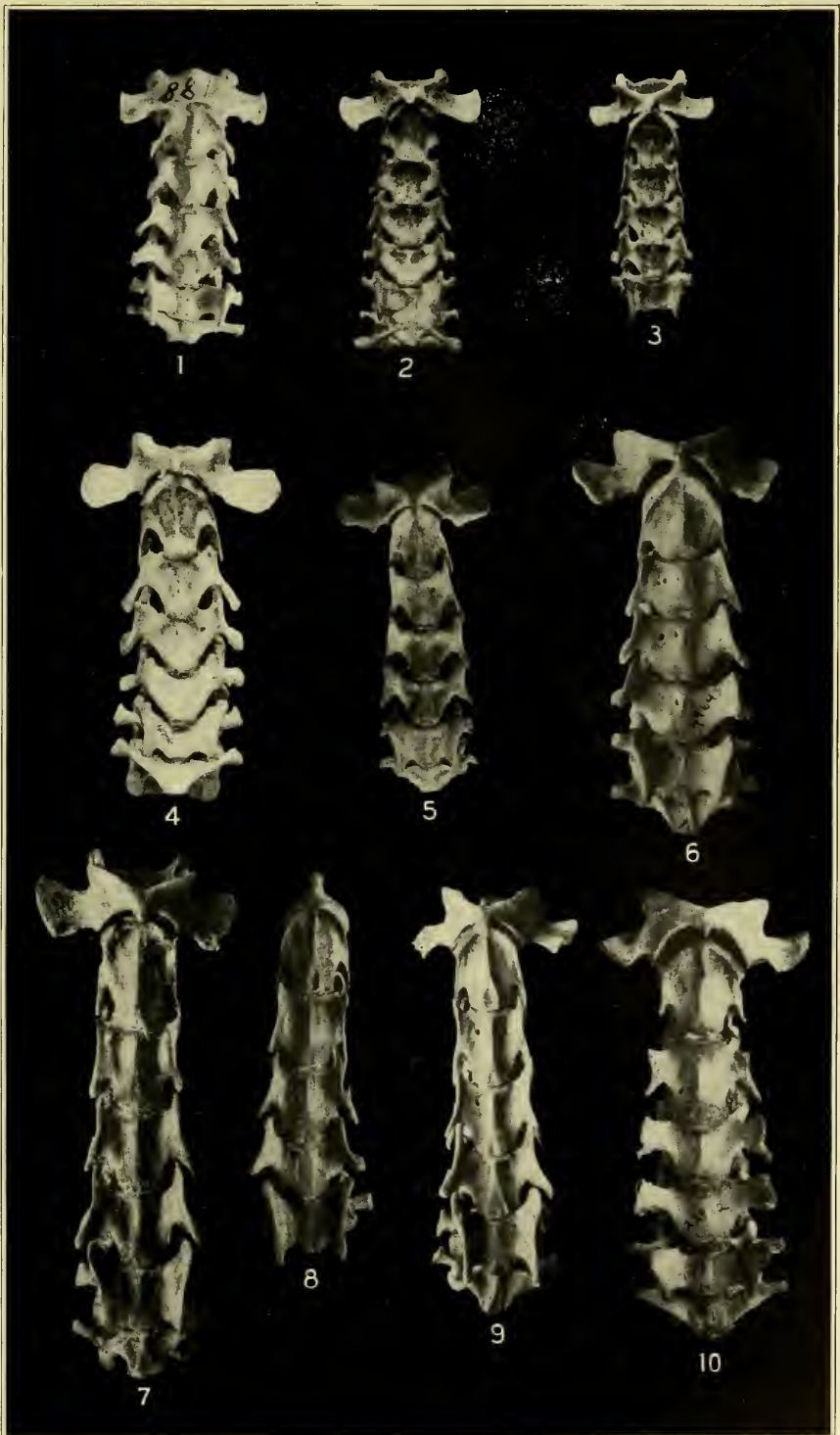
The third, fourth, and fifth have spine-like transverse processes directed backward. The sixth and seventh have well-developed transverse processes, not so spine-like as they are in the third, fourth, and fifth, and they project outward.

In the fourth, fifth, and sixth, the costal process is well developed as an expanded plate projecting laterally from the centrum and extending farther both cephalad and caudad than the centrum to which it is attached. With the true transverse process, this plate encloses the vertebral foramen. This plate-like expansion is largest in the sixth cervical, steadily decreases in size in each further cephalad vertebra, is merely indicated in the third cervical, and in the axis is seen only as the ventral wall of the vertebral foramen.

The seventh cervical is very similar to the first dorsal, differing from it in that it has on each side a vertebral foramen and no facets for the articulation of ribs.

The articulating surfaces of the centra are oblique, sloping from above downward and backward.

The laminae of the axis, of the third, and of the fourth are well developed, forming a complete roof for the spinal canal. The laminae of the fifth are less extensively developed, and of the sixth



CERVICAL VERTEBRÆ OF HARES, RABBITS, AND PIKAS. For explanation see page 445.



and seventh still less so, forming only a narrow arch over the vertebral canal.

Not many variations are found in the cervical vertebræ in the different genera of the Leporidae, but in general two forms occur:

First, large rabbits, in which the individual vertebræ are uniformly lengthened, and in which the costal process does not project laterally from the centrum to a marked extent, and the anterior and posterior spines of the costo-transverse process are more elongated. Cervical vertebræ of this type are found in all the skeletons belonging to the genus *Lepus*.

Second, rabbits averaging smaller in size in which the individual cervical vertebræ are uniformly shortened and in which the costal process projects further laterally from the centrum than it does in the first group, the anterior and posterior spines of which are less pronounced. The true transverse process is slightly more conspicuous here, and often begins to project laterally from the vertebra, beginning with the fifth cervical instead of with the sixth as in the case of the more elongated type of cervical vertebræ. All the genera of the family Leporidae, with the exception of the genus *Lepus*, belong to this section.

The most extreme development of the shortened type of cervical vertebræ is seen in *Pronolagus*, in which the costal process stands out still farther from the body of the vertebra. The process is narrower, that is, its antero-posterior dimensions are relatively much less than they are in the other genera. The cephalad and caudad projecting spines of the costal processes are apparently not well developed, but they have a somewhat worn or damaged look in the only specimen examined. The general appearance of the cervical vertebræ in *Pronolagus*, when viewed from below, is much as it is in *Ochotona*.

*Thoracic Vertebræ*.—There are twelve thoracic vertebræ, of which the more anterior are wider from side to side than they are long, while the reverse is true of the posterior vertebræ. The general size of each individual vertebra increases as one passes from before backward.

The centra, often at the beginning of the thoracic series and nearly always toward the end of it, have a low ventral median ridge, which on some of the anterior lumbar vertebræ is produced into a spine, the hypophysis.

In the first eight vertebræ of the thoracic series, the transverse processes are well developed and each is furnished with a large facet for articulating with the tubercle of the rib. In the ninth,

tenth, eleventh, and twelfth thoracic vertebræ, as a rule, the transverse process is absent, the ribs attached to these vertebræ articulating with the facets on the sides of the bodies only. In each of the last four thoracic vertebræ, each transverse process is replaced by a metapophysis on the anterior part of the vertebra, usually indicated by a tubercle on the eighth thoracic, and steadily increasing in size through the twelfth thoracic and still further increasing in size on the lumbar vertebræ. On the side of each of the four above vertebræ posteriorly, there is found another process, smaller than the above, the anapophysis. It is first seen in the ninth thoracic, is usually largest on the tenth, and decreases in size on the eleventh and twelfth. The large transverse processes which are found on the lumbar series are represented on the eleventh and twelfth thoracic by low lateral ridges.

The spinous or neural process of the first thoracic vertebra is very short and broad, inclined slightly backward. The neural spines of the succeeding eight vertebræ are all broad at the base, but spine-like at the free extremity, all are strongly directed backward. The spine of the ninth thoracic is broader than the spines of the vertebræ in front of it. The spine of the tenth thoracic vertebra is still broader from before backward, and usually the spine of this vertebra is inclined neither forward nor backward, that is, as the rule, it is the anticlinal vertebra. The spines of the eleventh and twelfth are still broader, and like the spinous processes of the lumbar vertebræ are directed forward.

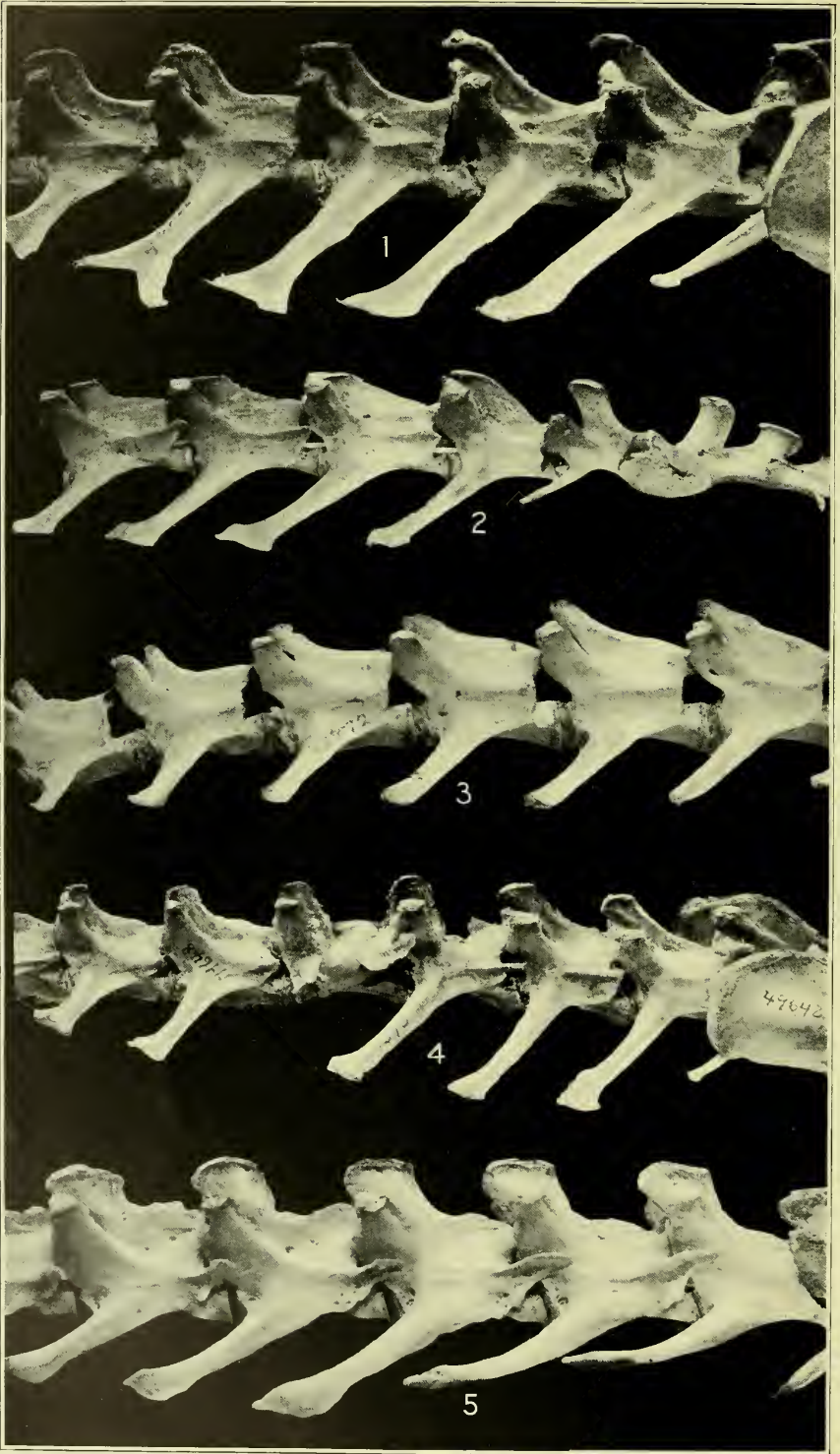
The first vertebra presents a whole facet at the anterior edge of the centrum for the head of the first rib, a half facet at the posterior edge of the centrum for half of the head of the second rib. From the second to the eighth thoracic vertebræ, inclusive, there is a half facet at the anterior edge and another half facet at the posterior edge of the centrum. The ninth thoracic vertebra has only a half facet at the anterior edge of the centrum. The tenth, eleventh, and twelfth have a whole facet each on the centrum anteriorly.

The transverse process of the first thoracic vertebra has a small concave facet for articulating with the tubercle of the rib. All the other vertebræ to and including the ninth have similar facets which increase in size up to the fifth and then decrease in size again. The tenth, eleventh, and twelfth thoracic vertebræ have no transverse processes.

Variations in the thoracic vertebræ are fewer than they are in the cervical vertebræ of the Leporidae. Some of the variations do not

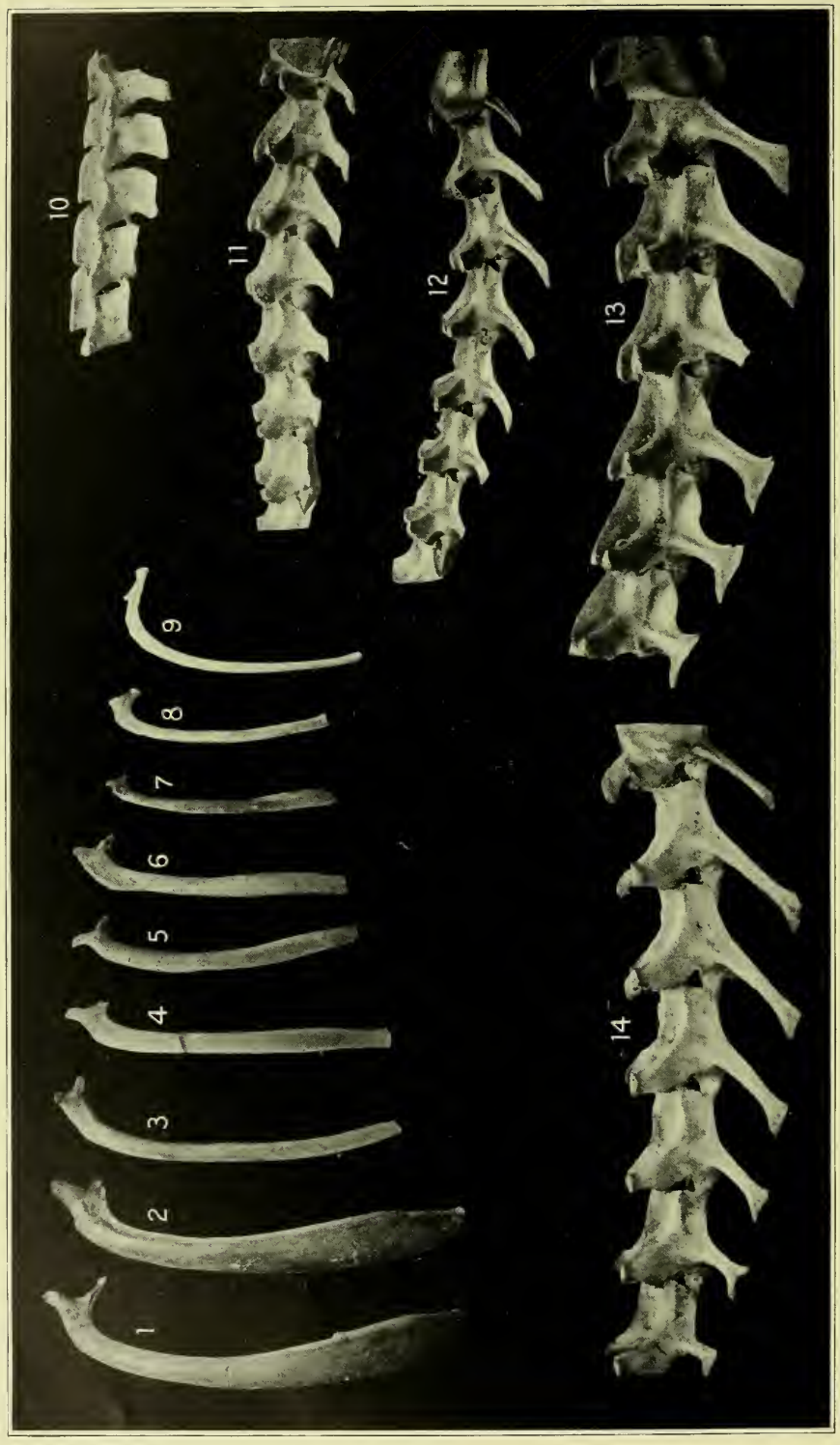






LUMBAR VERTEBRÆ OF HARES AND RABBITS (natural size). For explanation see page 446.





RIBS AND LUMBAR VERTEBRÆ OF HARES, RABBITS, AND PIKAS. For explanation see page 446.

seem to be more than individual, and the most that can be said is that they are tendencies rather than fixed characters.

The relative length of the neural spines in the anterior part of the thoracic series of vertebræ varies fairly constantly as follows: In *Romerolagus*, the length of an anterior neural spine is about twice the length of the centrum of the vertebra to which it is attached; in *Sylvilagus*, *Brachylagus*, *Limnolagus*, *Lepus* (*Pacilolagus*), and *Pronolagus*, the spine equals about two and a half times the centrum; in true *Lepus* it is about three times the length of the centrum, and in *Macrotolagus* and *Oryctolagus* it is a trifle over three times.

The position of the anticlinal vertebra varies between the tenth and eleventh thoracic as follows: It is the tenth in *Brachylagus*, *Limnolagus*, and *Romerolagus*; it is usually the eleventh in *Lepus*, *Sylvilagus*, *Oryctolagus*, and *Pronolagus*, but in some cases it is the tenth.

Metapophyses are always found well developed on the last three thoracic, but in *Pronolagus*, *Limnolagus*, and most of the members of *Lepus*, a well-developed metapophysis is also found on the ninth thoracic; this also happens frequently in the case of the genus *Sylvilagus*. But even those cases when the metapophysis is well developed on the tenth and eleventh thoracic only, it is always indicated by an ill-defined tubercle on the ninth.

*Lumbar Vertebræ* (pls. xciii, xciv).—The seven lumbar vertebræ are large and elongated. Each is provided with a stout, broad, spinous process, much shorter than the spines of the thoracic vertebræ. The metapophysis is well developed in all the lumbar vertebræ, and in the lumbar series nearly equals the spinous process in size. Like the spinous processes, the metapophyses are directed forward. On the anterior five lumbar vertebræ the anapophysis is represented by a horizontal line ending posteriorly, usually, in a small projecting spine. In some cases this little spine is practically absent, while in others it is very well developed.

The transverse processes of the lumbar vertebræ are very large and long, projecting downward and forward. The proximal end arises from the anterior third or half of the side of the centrum. The free extremity is usually enlarged, and in the more anterior vertebræ of the lumbar series it is usually bifurcated. The total length of a transverse process in the middle of the lumbar series is usually equal to one and one-half times the length of the centrum to which it is attached.

Each of the second and third lumbar vertebræ has a prominent ventral spine, the hypophysis. A smaller hypophysis is found in the first lumbar, and on the twelfth thoracic and the fourth lumbar vertebræ the hypophysis is usually indicated by a low ventral ridge on the centrum.

The zygopophyses are prominent in the lumbar vertebræ, and the articulating surfaces are directed laterally instead of horizontally as is the case with the cervical and thoracic series of vertebræ.

The last lumbar vertebra is peculiar in being shorter than any of the others and in having shorter and more slender transverse processes.

The lumbar vertebræ of the Leporidæ possess several well-marked variations, constant for certain groups and making good characters by which to determine them. The most important variations occur in the length, shape, and attachment of the transverse processes, and they may be outlined as follows:

1. Large rabbits having wide and long transverse processes with the free extremity expanded. The length of the longest process equals the length of the centrum to which it is attached and half the length of the centrum in front. The attached portion of the transverse process rises abruptly from the anterior half of the side of the centrum. All the members of the genus *Lepus* have the transverse processes of the lumbar vertebræ of this form.

2. Medium sized rabbits having the lumbar transverse processes of the same relative length and width as in the above group. Instead, however, of arising abruptly from the anterior half of the lateral aspect of the centrum, each process has a rather long posterior root coming from nearly the whole of the posterior half of the centrum, sharply sloping into the process itself. The skeletons having such transverse processes on the lumbar vertebræ belong to the genera *Sylvilagus* and *Oryctolagus*.

3. Medium-sized rabbits with the transverse processes slightly shorter than they are in the two preceding groups, the longest process equaling the length of the centrum to which it is attached and a fourth of the centrum in front. The processes are much broader than they are in the former groups, so that they appear much shorter than they really are. The free extremities are more expanded than they are in any of the genera except *Romerolagus*. The attached bases are very wide, coming from the whole side of the centrum, and the angle between the main axis of the transverse process and the side of the centrum is filled in with thin bone especially marked in the anterior part of the lumbar series, approach-

ing the condition found in *Romerolagus*. These processes are characteristic of the genus *Limnolagus*.

4. Small rabbits having the lumbar transverse process slightly more concave anteriorly than in the other rabbits. Each process is marked by a prominent longitudinal ridge. But for this pronounced ridge the lumbar transverse process resembles that found in the genus *Sylvilagus*. While this ridge is found to a greater or less extent in the other groups of the Leporidae, yet it is never so narrow nor so sharply marked off from the rest of the process. The transverse processes of this type are peculiar to the genus *Brachylagus*.

5. Small rabbits with the lumbar transverse processes short, the longest equaling the length of the centrum to which it is attached. The process of the first lumbar vertebra is very short and almost rudimentary. All the processes are wide and have triangular outlines in general. The base is broad, coming from the whole side of the centrum, and the angle between the main axis of the process and the side of the centrum is completely filled with thin bone. It is an exaggeration of the condition found in *Limnolagus*. Even the transverse process of the last lumbar vertebra, which is usually slender in other rabbits, is here very broad, but not so broad as the transverse processes on the other lumbar vertebrae. Transverse processes of this type are characteristic of the genus *Romerolagus*.

6. Medium-sized rabbits with lumbar transverse processes of medium length, the longest equaling the length of the centrum to which it is attached. The process is not so much expanded at the free extremity as in the case of the above groups. It is wide however at the base, where it comes from the whole side of the centrum, resembling in this respect *Limnolagus*, but the posterior border of the transverse process is not so strongly concave as in that genus, and the process itself is more slender. Transverse processes of this type are found in the genus *Pronolagus*.

The other variations in the lumbar vertebrae are of less importance and not so well defined as are the variations of the transverse processes.

The spinous processes and metapophyses are always well developed. In the anterior part of the lumbar region the spinous processes are usually a little longer than the metapophyses on the same vertebra and they are always longer in the posterior region. The spinous process is of variable shape and there are marked differences in individuals of the same species. This process is, in general, bluntly triangular, sloping obliquely anteriorly, the basal

side attached to the rest of the vertebra, with a long sloping or usually concave posterior edge, and a more nearly vertical and shorter anterior edge.

In the following hares the spinous processes are perfectly triangular, and are relatively not so high as in the typical form: *Romerolagus*, *Limnolagus*, *Pronolagus*, *Pacilolagus*. One skeleton of the genus *Sylvilagus* (No. 94,197, from Monitor valley, Nevada) also has neural spines of this shape, although in the other members of this genus which I have noted they are of the typical form.

The anapophyses are very slightly developed on the lumbar vertebræ of all hares. Their presence is usually indicated by a mere ridge on the side of the vertebræ, which ends in a small caudad projecting tubercle. They are least developed in the skeleton of *Pronolagus* and are longest in the skeleton of a lop-eared domestic rabbit, *Oryctolagus cuniculus*. Here they are very large, and in the three middle vertebræ of the lumbar series, viz., third, fourth, and fifth, the anapophysis extends as far posteriorly as the posterior border of the metapophysis of the next succeeding vertebra. In the wild *Oryctolagus*, however, this great development of the anapophysis is not so pronounced, but it is much larger than on the lumbar vertebræ of any of the other skeletons.

Ventral spines, or hypophyses, or ridges indicating them, are found on the first three lumbar vertebræ. The spines usually occur in three lengths: In the genera *Sylvilagus* and *Brachylagus* the hypophysis on the second lumbar is the longest, that on the first lumbar is next in length, and the shortest hypophysis is found on the third. Occasionally in *Sylvilagus* the first hypophysis is reduced to a ridge and the last is sometimes lacking. In all the skeletons of the genus *Lepus* the third lumbar vertebra bears the longest hypophysis; the first bears the shortest. In *Romerolagus* the first hypophysis is the shortest, the second and third are subequal, the third being a trifle the larger. In the skeletons of *Limnolagus*, *Pronolagus*, and *Oryctolagus* the hypophyses are more or less injured. It would appear, however, in these genera that the second hypophysis is the longest.

*Sacral Vertebra.*—The number of sacral vertebræ in the Leporidae varies from three to five, according to the age of the individual, four being the usual number. The two anterior vertebræ of the sacrum are the only ones entering into the formation of the sacroiliac joint. The remaining vertebræ are progressively smaller and resemble in shape the anterior caudal vertebræ.

The first sacral has a large neural spine, vertical or inclined



slightly forward like the spines of the lumbar vertebræ. The neural spines of the remaining sacral vertebræ become progressively smaller from before backward and they are directed caudad. In some cases the spine of the fourth sacral is very small. In nearly all cases the spines of the sacral vertebræ are distinct and not fused with one another.

The outline of the sacrum as a whole is triangular, the base being in front, the apex behind. The greatest width, which is at the anterior part of the massive fused transverse processes of the first and second sacral vertebræ, is nearly equal to the greatest antero-posterior diameter.

In all the rabbits the sacrum presents very few variations. The differences found in the different sacra seem to be due entirely to age and individual variations. The only sacrum showing any marked deviation from the type is in *Lepus sp.* No. 49,621, from Jumna river, India. The posterior part of this sacrum is very narrow from side to side. The expanded wing-like portions to which the ilia are attached are very narrow from before backward. In general, the shape of this peculiar sacrum, as seen from below, is like a T. The adjacent tips of the first and second, and of the third and fourth of its sacral neural processes are in contact.

The usual number of vertebræ in the sacrum is four; in some old individuals it is raised to five, and in some younger ones it is only three. In what follows with reference to the caudal vertebræ, four vertebræ will be considered as entering into the formation of the sacrum.

*Caudal vertebræ.*—The caudal series always includes vertebræ of three different though not sharply defined forms.

1. The first one or two vertebræ following the sacrum are long, and in general appearance resemble the last sacral vertebra.

2. The next three to seven caudal vertebræ are shortened, have wing-like anteriorly directed transverse processes and the neural arches become progressively less developed caudad.

3. The remaining vertebræ of the caudal series, four to nine in number, are merely small elongated centra without processes or neural arches.

The accompanying table (page 364) shows the number of the different forms throughout the caudal series in the available skeletons. From this table the following groups may be picked out:

1. *Nesolagus*, with a total of eight caudal vertebræ.
2. *Romerolagus*, with a total of nine caudals, of which one is of the first form, five of the second, and three of the third.

GENERA AND SPECIES.	LOCALITY.	NUMBER.	FORMS.			Total Number.
			No. of 1st Form.	No. of 2d Form.	No. of 3d Form.	
<i>Lepus (Lepus) timidus</i> .....	Sweden	1,048 <sup>1</sup>	1	7	5	13
“ “ “.....	“	1,049 <sup>1</sup>	1	7	5	13
“ “ <i>campestris</i> .....	Kansas.	43,623 <sup>1</sup>	1	7	6	14
“ “ “.....	Nebraska.	49,622 <sup>1</sup>	1	7	6	14
“ “ <i>gichiganus</i> .....	Siberia.	18,303 <sup>2</sup>	2	5	5	12
“ ( <i>Macrotolagus</i> ) <i>texianus</i> .....	Nevada.	94,198 <sup>3</sup>	1	7	7	15
“ ( <i>Pocilolagus</i> ) <i>americanus</i> <i>virginianus</i> .....	New York.	969 <sup>1</sup>	1	7	*	*
“ <i>sp.</i> .....	India: Jumna river.	49,621 <sup>1</sup>	1	6	7	14
<i>Sylvilagus floridanus</i> .....	Florida.	49,586 <sup>1</sup>	1	6	7	14
“ “ “.....	“	49,587 <sup>1</sup>	1	7	6	14
“ “ “.....	“	49,588 <sup>1</sup>	1	5*	*	*
“ “ “.....	“	49,589 <sup>1</sup>	2	6	7	15
“ “ <i>mallotus</i> .....	Virginia.	89,514 <sup>3</sup>	1	6	6*	13*
“ “ <i>transitionalis</i> .....	New York.	49,624 <sup>1</sup>	2	6	7	15
“ “ subspecies.....	Nevada.	94,197 <sup>3</sup>	1	6	5*	13*
“ <i>nuttallii</i> .....	Wyoming.	11,644 <sup>1</sup>	1	6	6	13
“ <i>truei</i> .....	Mexico.	92,965 <sup>3</sup>	1	6	*	*
“ <i>minensis</i> .....	Brazil; Chapada.	113,432 <sup>1</sup>	2	5	4	11
“ “ “.....	“	49,665 <sup>1</sup>	2	5	4	11
<i>Brachylagus idahoensis</i> .....	Idaho.	93,695 <sup>3</sup>	2	3	4	9
“ “ “.....	“	93,596 <sup>3</sup>	2	3	4	9
<i>Nesolagus netscheri</i> <sup>4</sup> .....	Sumatra.	?	?	?	?	8
<i>Romerolagus nelsoni</i> .....	Mexico.	57,954 <sup>3</sup>	1	5	3	9
<i>Limnolagus paludicola</i> .....	Florida.	49,580 <sup>1</sup>	1	5	5	11
<i>Oryctolagus cuniculus</i> , lop ear.....	domestic.	49,386 <sup>1</sup>	1	7	9	17
“ “ “.....	Germany.	49,645 <sup>1</sup>	1	6	9	16
“ “ “.....	England.	49,648 <sup>1</sup>	1	8	8	17
“ “ Belgian hare..	domestic.	49,677 <sup>1</sup>	1	7	9	17
<i>Pronolagus crassicaudatus</i> .....	South Africa.	22,972 <sup>1</sup>	2	*	*	*

3. *Brachylagus*, with a total of nine caudals, of which two are of the first form, three of the second, and four of the third.

4. *Limnolagus*, with a total of eleven, of which one is of the first form and five each of the second and third.

The other genera containing a larger number of species than the above do not show such sharply defined results, but they roughly fall into these groups.

5. *Sylvilagus*, having a total of eleven to fifteen caudals, of which usually the first one or two are of the first form, the next five or seven, usually six, of the second form, and the terminal four or seven of the third form.

<sup>1</sup> United States National Museum.

<sup>2</sup> American Museum of Natural History.

<sup>3</sup> United States National Museum, Collection of Biological Survey, United States Department of Agriculture.

<sup>4</sup> No specimen seen, taken from original description. (Schlegel, '80, p. 64.)

<sup>5</sup> Series incomplete.

6. *Lepus*, having a total of thirteen to fifteen caudals, of which the first only is of the first form, the next five to seven, usually seven, of the second form, and the remaining five to seven of the third form.

7. *Oryctolagus*, with a total of sixteen to seventeen caudals, of which the first is of the first form, the next six or eight of the second, and about the remaining eight or nine of the third form.

#### OCHOTONIDÆ

The vertebral column of the Ochotonidæ presents nearly as many and as marked differences from that of the Leporidæ as do the skulls of the former from those of the latter.

*Cervical Vertebrae* (pl. XCII, 1).—The cervical vertebrae of the Ochotonidæ have the same general characteristics as in the Leporidæ. They are decidedly shortened antero-posteriorly, the laminae of the posterior ones being very narrow. This shortening involves the axis but not the atlas. The latter has the free extremity of the transverse processes moderately expanded. The costo-transverse processes of the third, fourth, and fifth cervicals are placed more obliquely to the axis of the vertebral column than the same processes are in the Leporidæ. In the sixth they become horizontal as they do in the hares. The transverse process of the seventh cervical differs from that in the Leporidæ in not being pierced by a costo-transverse or vertebral foramen.

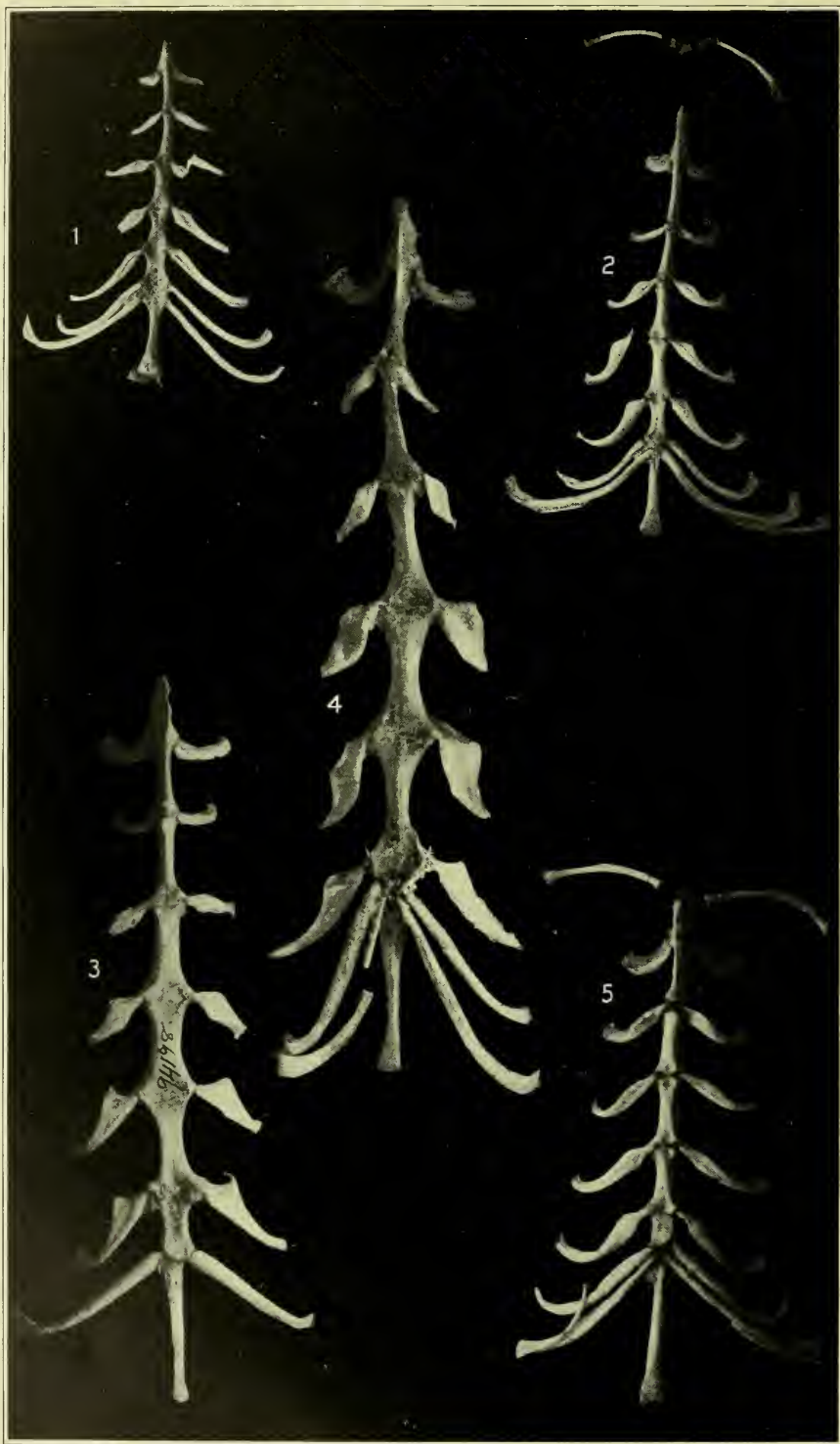
*Thoracic Vertebrae*.—The thoracic vertebrae of the Ochotonidæ are entirely different from the same series of vertebrae in the Leporidæ, they are 17 in number instead of 12, the thoraco-lumbar vertebrae in the two groups being 22 and 19 respectively. The first 12 of the thoracic vertebrae in the Ochotonidæ are exactly homologous with the 12 thoracic vertebrae of the Leporidæ. The arrangement of the facets for the heads and the tubercles of the ribs is entirely similar. The five remaining rib-bearing vertebrae of the Ochotonidæ are practically indistinguishable from one another as well as from the twelfth, except by the slightly greater size of each succeeding vertebra.

The spinous processes are relatively shorter in the Ochotonidæ, and this is especially true in the posterior thoracic region from the twelfth onward where the spines are all low and slightly inclined forward. Each neural spine of these posterior thoracic vertebrae arises by a broad base from the whole length of the neural arch; the free extremity of the process is nearly as long as the base, the posterior edge being slightly concave.

That part of the transverse process of the thoracic vertebra which articulates with the tubercle of the rib is the same in form in the two families. Associated with this transverse process in the Ochotonidæ are the metapophysis and the anapophysis. Both these processes are first seen on the third thoracic as mere tubercles. The anapophysis grows larger on each successive vertebra, attaining its greatest size on the last thoracic. From the eleventh thoracic onward, the anapophysis is a well-marked process directed upward, backward, and outward. The metapophysis remains little more than a tubercle until the tenth thoracic vertebra is reached, where it is a well-marked process. On the eleventh it is slightly larger, and on the twelfth still larger but closely associated with the prezygopophysis. The metapophysis scarcely increases in size through the rest of the series and continues closely associated with the prezygopophysis throughout. No ventral spines or hypophyses are found on any of the vertebræ. Some of the posterior thoracic have a slight ventral ridge which is also found on all the lumbar vertebræ.

*Lumbar Vertebræ* (pl. XCIV, 10).—Corresponding to the greater number of the thoracic vertebræ in the Ochotonidæ, there is a diminution in the number of the lumbar vertebræ, from 7 to 5, but this is not sufficient to make the number of thoraco-lumbar vertebræ the same in the two families. The lumbar vertebræ of *Ochotona* are very different in form as well as in number from those of *Lepus* and its allies. Each vertebra is compact, with the processes broader and more closely applied to the body instead of the slenderer processes extending to a distance from the centrum such as occurs in the Leporidæ. The neural process is low, with the free edge as long as the whole length of the vertebra and parallel with the axis of the vertebra. The metapophyses are well developed and more closely associated with the prezygopophyses than they are in the Leporidæ. Anapophyses are well developed on the first and second lumbar vertebræ and are a direct continuation of the thoracic series of anapophyses. These processes are slightly indicated on the third lumbar vertebra, after which point they disappear. The transverse process is little more than a tubercle on the first and second lumbar vertebræ, but on the third and fourth it is a wide quadrilateral plate of bone coming from the whole side of the vertebræ, sloping downward and outward. The transverse process of the fifth and last lumbar is a trifle longer than the other transverse processes and only about half as wide, the narrowing taking place chiefly at the expense of the posterior half of the process. There are no hypophyses, but all the lumbar vertebræ (as is the case of those lumbar vertebræ of





STERNA OF HARES AND RABBITS (natural size). For explanation see page 446.

the Leporidae which do not bear ventral spines) possess a median ventral ridge.

*Sacral Vertebrae*.—The sacrum in the pikas is entirely different in form from the corresponding structure in the hares and rabbits. It is long and narrow, its greatest breadth being contained in its length about twice. The lateral masses that are attached to the ilia, instead of being expanded into wing-like processes with the greatest width anteriorly, are much less expanded and have nearly parallel sides. The neural spines so distinct and conspicuous on the sacra of the Leporidae are reduced in the Ochotonidae to form a low dorsal ridge, the separate spines having fused with one another. The number of vertebrae entering into the formation of the sacrum of the Ochotonidae is four, the same as in the case of the Leporidae.

*Caudal Vertebrae*.—The caudal vertebrae in the Ochotonidae are eight in number in all the skeletons at hand except one, which has nine. In three American specimens, Nos. 91,188 and 30,990 from Idaho, and No. 49,620 from Oregon, the first caudal is somewhat narrowed, the next two are slightly wider, with faint indications of lateral projections; the rest of the series consists of short flattened bodies. The single Asiatic skeleton, No. 49,500, *Ochotona lada-censis*, central Asia, has mainly the same character of the caudals, but the individual vertebrae are relatively wider throughout.

## STERNUM

### LEPORIDÆ

(PLATES XCV, 1-5; XCVI, 1, 3-5)

The sterna of the Leporidae are formed of the usual three portions, presternum or manubrium, mesosternum or gladiolus, and xiphisternum.

The presternum consists of one piece which is usually longer than any other single segment of the sternum excepting the xiphisternum. It is usually compressed from side to side and marked by a more or less evident ventral keel. At or anterior to its middle the first pair of sternal ribs is attached.

The mesosternum consists of four usually distinct segments. A sternal rib is attached at the point of articulation of each segment with the other, as well as at the point of articulation of the presternum with the mesosternum. At the posterior outer aspect of the last mesosternal segment near the articulation of the xiphisternum two sternal ribs are usually attached.

The xiphisternum is usually the longest single segment. It is attached anteriorly to the last mesosternal segment. Its posterior end is free and is terminated by a thin rounded piece of cartilage.

Eight different types of sternum are found among the Leporidæ; some of which are characteristic of certain genera, while the others are not so sharply defined and might better be considered tendencies rather than actual developments. A greater number of skeletons may show that some of the types amount to nothing, as there seems to be a certain amount of variation in individuals of the same species. The different types of sterna are as follows:

1. Presternum long and narrow, much compressed laterally into a keel which is most prominent anteriorly; the first rib is attached at the junction of the first and second fourths or first and second thirds. Mesosternum of four distinct segments, of which the first is narrow and compressed, the others not compressed or even flattened dorso-ventrally. All the mesosternal segments in general are subequal and each successive one grows wider from before backward. The xiphisternum about equals the presternum in length. The anterior end is considerably enlarged where it articulates with the last mesosternal segment. Its posterior and free extremity is rather pointed or only slightly larger than the narrowest portion of the xiphisternum. One skeleton (*Lepus texianus*, No. 94,198), belonging in this section, has an anomalous mesosternum composed of five distinct segments, the last of which is only slightly smaller than the other segments. At the articulation of the mesosternum with the xiphisternum, but one pair of ribs is attached instead of the usual two pairs in sterna where the fifth mesosternal segment is normally suppressed.

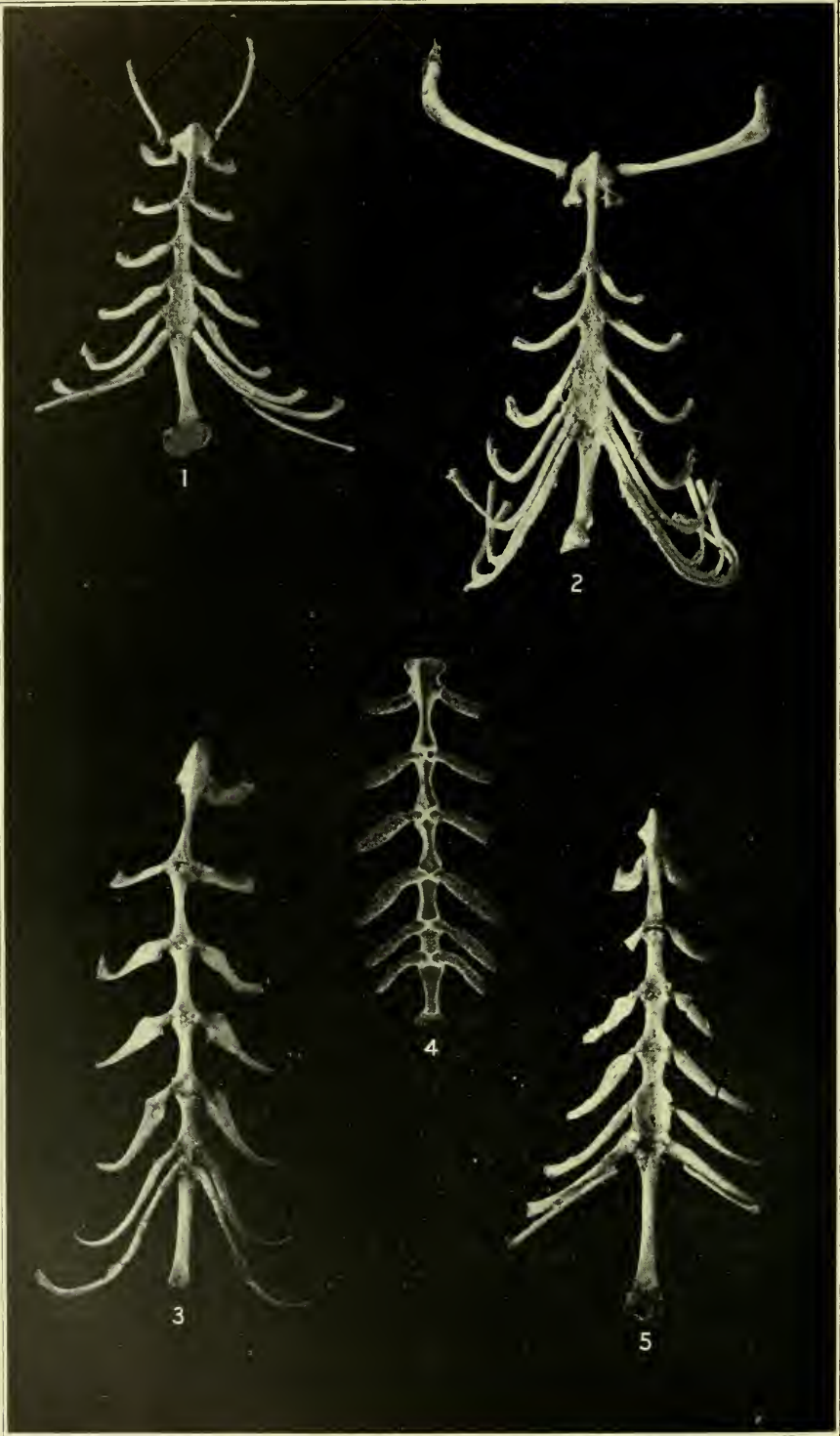
The hares possessing sterna like the above are all large and belong to the genus *Lepus*. (Pl. xcv, 3, 4.)

2. Sternum in general very similar to the above, presternum relatively longer, its keel less prominent anteriorly. The first pair of ribs is attached just anterior to its middle. The mesosternal segments have a tendency to be less flattened. Xiphisternum shorter than the presternum, its posterior end more enlarged than it is in the case of the preceding section. Such sterna are more or less characteristic of the genus *Sylvilagus*. (Pl. xcv, 2.)

3. Sterna similar to those of the genus *Lepus*; presternum more conspicuously keeled, the first rib attached just anterior to its middle. Mesosternal segments more compressed from side to side than they are in *Lepus*. The last is much shorter than any of the other mesosternal segments. Xiphisternum large and stout, longer than the







STERNA OF RABBITS AND PIKA. For explanation see page 446.

presternum, its posterior extremity about as much expanded as its anterior. These sterna are found in the genus *Oryctolagus*. (Pl. xcv, 5.) One skeleton of *Oryctolagus* (No. 49,648) shows the peculiarity of five segments in the mesosternum, the fifth being very small and short. As in the case of the abnormal sternum of *Lepus texianus*, No. 94,198, also with five mesosternal segments, only one pair of ribs is attached to the junction of the fifth mesosternal segment with the xiphisternum.

4. Presternum compressed with low keel all along ventral border, dorsal portion somewhat expanded just anterior to the attachment of the first pair of ribs which takes place at the junction of the anterior and middle thirds. Mesosternum of four distinct segments, the first compressed laterally with a low keel continuing that of the presternum, the succeeding mesosternal segments becoming successively wider and more dorso-ventrally flattened. The last segment is much wider than any of the others, with a well-marked postero-lateral angle for the attachment of the last two sternal ribs. The xiphisternum is decidedly longer than the presternum; it is slender in the middle, but the ends are considerably expanded, especially the posterior end. This type of sternum is found in the genus *Brachylagus*. (Pl. xcv, 1.)

5. Posterior two thirds of the presternum much compressed, but not keeled. The anterior third is somewhat expanded, resembling that portion of the presternum of *Limnolagus*. The first pair of ribs is attached at the junction of the first and second fourths. The mesosternal segments are more compressed laterally than they are in the other skeletons and each succeeding one is a little shorter than the one immediately in front of it. The xiphisternum is a trifle shorter than the presternum, is comparatively short, and about equally widened at each end. This type of sternum is found in the single skeleton of *Pronolagus*. (Pl. xcvi, 3.)

6. The anterior portion of the presternum is considerably expanded laterally, having a tendency to be intermediate in form between the presterna of *Lepus* and those of *Romerolagus* and *Ochotona*. The mid-ventral line of this expanded part bears a low keel which is not extended backward on the posterior portion of the presternum. The first pair of ribs is attached to the middle of the presternum. The mesosternum as a whole is wider than are the mesosterna previously mentioned. It is also shorter, so that its length is but little greater than that of the presternum or of the xiphisternum, both of which are about equal in length. The first, second, and third mesosternal segments are about equal in length; each

succeeding segment is wider than the one in front. The third and fourth mesosternal segments are completely ankylosed so that the whole mesosternum is composed of but three separate pieces instead of the usual four. The xiphisternum is long and slender and about equally expanded at each end. In all the preceding sections the sixth and seventh pairs of ribs are attached to the last piece of the mesosternum in the angle between it and the xiphisternum. In case of the form of sternum just described the sixth rib is the last attached directly to the sternum, the seventh being attached to the cartilage of the sixth near the point where the latter joins the mesosternum. This type of sternum is found in the skeleton of *Limnolagus paludicola*. (Pl. xcvi, 5.)

7. In this section the sternum is very characteristic and resembles almost exactly that of *Ochotona*. The anterior portion of the presternum is very much expanded and flattened dorso-ventrally. To the outer posterior angles of this expanded portion the first pair of ribs is attached. The rest of the presternum is long and narrow, as it is throughout the Leporidae, but devoid of any ventral keel. A slight ridge indicating a keel is seen on the ventral face of the expanded portion. The mesosternum in general is very much like the same structure in *Limnolagus* just described. The first and second segments, however, are subequal and relatively narrower, the third and fourth segments are subequal in length, but the fourth is broader, both are relatively wider than they are in *Limnolagus* and as in that genus are firmly ankylosed. The xiphisternum is long and rather stout; it is about equally enlarged at either end. It is but a trifle shorter than the whole mesosternum and decidedly longer than the presternum. As in *Limnolagus* the seventh pair of ribs does not articulate with the sternum, but with the cartilages of the sixth pair. The above is the sternum of *Romerolagus*. (Pl. xcvi, 1.)

8. In this group the presternum is considerably enlarged in its anterior third, to about the same extent that it is in *Romerolagus*. Its different shape is best seen by consulting figures 1 and 4, plate xcvi. The mesosternum consists of four distinct segments, the first two subequal in length, compressed laterally; the third segment is slightly shorter, not laterally compressed; the fourth segment is very short and cartilaginous. The xiphisternum is very short, much shorter than the presternum; its anterior end is considerably enlarged. Apparently six pairs of ribs only articulate directly with the sternum. This type of sternum is found in *Nesolagus* (Major, '99, pl. 39, fig. 18).

## OCHOTONIDÆ

(PLATE XCVI, 2)

The material for making generalizations concerning the sterna of the Ochotonidæ is far from being satisfactory. Out of four skeletons but one is fully adult and there is a certain amount of variation among them. It may be that more material would show that there are two or three different types of sterna among the Ochotonidæ. Aside from a few minor details the sternum of the only adult *Ochotona* at hand, No. 91,188, is almost exactly like the sternum of *Romcrolagus* just described, so that the genus *Romerolagus* can be briefly described as a rabbit with the sternum of a pika. The expanded portion of the manubrium is less developed in *Ochotona* than in *Romerolagus*, and rather triangular in outline instead of pentagonal. In other respects the two sterna are similar. The *Ochotona* presternum is nearly as long as the mesosternum and slightly longer than the xiphisternum.

The mesosternum of *Ochotona* is in general very similar to that of *Romcrolagus*. The first and second segments are subequal in length, the second being broader however. The third segment is the longest and broadest of the mesosternum. The fourth segment is the shortest and nearly as broad as the third. Both the third and fourth mesosternal segments are completely ankylosed as they are in *Romerolagus* and *Limnolagus*.

The xiphisternum is considerably expanded at the proximal end, but the distal extremity is not much enlarged. It is decidedly shorter than the presternum.

The seventh rib is attached along with the sixth rib to the sternum at the point of union of the mesosternum with the xiphisternum.

No. 30,990 *Ochotona saratilis*, Idaho, is very similar to the above; it is young, however, and the third and fourth pieces of the mesosternum are not yet fused.

No. 49,620, from Oregon, has the entire mesosternum narrow and its last two segments separate.

No. 49,500 *Ochotona ladacensis*, Ladak, central Asia, has the enlarged portion of the presternum less expanded; the mesosternum is relatively longer and decidedly narrower than is the mesosternum of *O. saratilis*, the third and fourth mesosternal segments are not fused. The mesosternum as a whole bears considerable resemblance to some of the mesosterna of *Sylvilagus*. The xiphisternum is rather short.

## RIBS

## LEPORIDÆ

(PLATE XCIV, 1-8)

Corresponding to the number of thoracic vertebræ there are twelve pairs of ribs of which seven are normally attached to the sternum by means of well developed, ossified, costal cartilages. The last three or four pairs of ribs have no ventral attachments. The ribs intervening between the sternal and floating ribs are attached by their costal cartilages to the costal cartilages of the sternal ribs.

The typical rib has a head attached to the centra of two adjoining vertebræ, a well-marked tubercle a portion of which articulates with the transverse process of the more anterior vertebra and another portion of which projects superiorly, forming a spine. The most posterior ribs lack the tubercle. The first rib has the articular portion of the tubercle well developed but the spine-like part is lacking. Its place, however, is taken by a dorsally projecting spine from the transverse process of the first thoracic vertebra. The rest of the rib is made up of a long, thin, flattened shaft.

In the genus *Lepus* the non-articular portion of the tubercles are very well developed, the eighth pair of ribs is the last pair bearing them. The second, third, fourth, fifth, and sixth ribs are very flat and broad in the ventral half of the shaft; the greatest width of the rib just behind the tubercle is very much less than the width of the shaft in the lower portion. The sternal costal cartilages in *Lepus* are very short and wide, as compared with the sternal costal cartilages of the other genera.

In *Oryctolagus* conditions similar to those found in *Lepus* exist regarding the ribs, but the shafts of the anterior ribs are relatively less widened.

The genus *Sylvilagus* closely resembles *Lepus* with respect to the form of the ribs, but like *Oryctolagus* the shafts of the ribs are less expanded and in some of the species, notably *S. minensis*, the non-articular portions of the tubercles are not so well developed and are last seen on the seventh pair of ribs.

*Brachylagus* closely resembles *Sylvilagus*, especially *S. minensis*; the non-articular portions of the tubercles are not very well developed and are last seen on the eighth pair of ribs.

In *Limnolagus* the tubercles are well developed but are not conspicuous, owing to the fact that the angle between the tubercle and the posterior edge of the rib is filled up with bone, making that part distinctly the widest portion. In the single skeleton at hand

the last rib to bear a spine-like tubercle on the right side is the seventh, while on the left side it is the sixth. The shafts of the anterior ribs are not widened ventrally.

The spines of the tubercles are very small in *Pronolagus*, and are last found in the seventh pair of ribs. The shafts of the ribs are relatively narrow and there is no indication of the wide expansion found in *Lepus*. Decidedly the widest part of the rib is just behind the spine.

*Romerolagus* very closely resembles *Pronolagus* in regard to the ribs, but the spines of the tubercles are last found on the sixth pair.

#### OCHOTONIDÆ

(PLATE XCIV, 9)

In the Ochotonidæ there are seventeen pairs of ribs of which the first seven are attached to the sternum by means of costal cartilages, the last seven pairs or about that number have no ventral attachments, while the three intermediate pairs are attached to the costal cartilages of the ribs in front. The ribs are all slender and weak compared with the ribs of the Leporidæ and none of them possesses spine-like, non-articular portions of tubercles, but just behind the tubercles the more anterior ribs are quite broad and heavy.

#### CLAVICLE

##### LEPORIDÆ

(PLATES XCV, 2, 5; XCVI, 1)

In the Leporidæ the clavicle is probably always present as a small curved, slender bone, about fifteen millimeters long. In most of the skeletons, however, the clavicles are wanting, undoubtedly the result of faulty preparation. In only four of the skeletons at hand have these bones been found. The uncleaned skeletons show that the clavicle does not articulate with either the sternum or the scapula as it does in those animals where it is well developed. Ligamentary tissue extends from its inner end to the presternum, while the outer end is attached to a piece of cartilage placed on the summit of the greater tuberosity of the humerus. In his account of the genus *Romerolagus* (Proc. Biol. Soc. Washington, x, 1896, December 29, p. 171) Dr. Merriam says: "The clavicle is complete and articulates directly with the sternum (fig. 33)—a thing that never happens in the genus *Lepus*." Whether that is the case with any of the other genera of the Leporidæ can not be told, owing to the faulty methods of cleaning the skeletons. It might be thought

that *Romerolagus* with the enlarged presternum would have clavicles much larger than those in the other genera of the Leporidae, but measurements show that the ratios of length of humerus to length of clavicle in *Romerolagus* is 3.20, in *Oryctolagus* 3.16, in *Sylvilagus* 4.00.

#### OCHOTONIDÆ

(PLATE XCVI, 2)

In the Ochotonidæ the clavicle is very well developed, the ratio of its length to that of the humerus is  $\frac{1}{2}$ . The outer end, enlarged and flattened, is connected by a ligament to the greater tuberosity of the humerus. The inner end articulates directly with the extreme anterior portion of the presternum.

#### SCAPULA

##### LEPORIDÆ

(PLATE XCVII, 1-4, 6-9)

The general shape of the scapula of the Leporidae is roughly that of a right triangle, with the right angle rounded off, and directed upward and forward. The acromion process is long and slender and about half the length of the actual scapular spine. Coming off at right angles to the acromion process and directed caudad is a well developed pointed metacromion.

The scapulæ of the Leporidae fall into three not very strongly marked groups:

1. Large rabbits, members of the genus *Lepus* in which the scapula is relatively broad, the superior border rather more convex, the antero-superior angle more rounded, and the suprascapular fossa relatively wider.

2. Rabbits averaging smaller in size, members of the genera *Sylvilagus*, *Oryctolagus*, *Brachylagus*, and *Limnolagus*, in which the scapula is relatively narrower, the superior border straighter and less convex, the antero-superior angle more pronounced and not so gradually rounded off as in the genus *Lepus*. The suprascapular fossa is relatively narrower.

3. *Romerolagus* and *Pronolagus* have scapulæ much alike and differing from the scapulæ of the other genera in being longer and narrower. The posterior border is more nearly straight instead of being concave as in the other two groups. The superior border is straighter. The distance between the antero-superior and the postero-superior angles is contained twice in the length of the scapula measured along the inner surface at the attachment of the





SCAPULÆ OF HARES, RABBITS, AND PIKAS (natural size). For explanation see pages 446, 447.



spine, from the superior border to the edge of the glenoid cavity. In the other rabbits the distance between the two superior angles is contained but one and one-half times in the scapular length.

#### OCHOTONIDÆ

(PLATE XCVII, 5)

The scapula of the Ochotonidæ is of a quite different type from that of the Leporidæ. The general outline of the bone is also that of a right triangle, but the right angle is very much rounded off and the general appearance of the scapula is more oblique. The acromion process is very long and slender, about twice the length of the actual scapular spine. The metacromion is well developed, and has about the same general proportion that it has in the Leporidæ. The posterior border of the scapula is long and more concave than in the Leporidæ; the superior border is relatively longer and very much rounded off, so that it gradually merges into the anterior border. The distance between the antero-superior and the postero-superior angles is relatively greater in the pikas than it is in the hares and rabbits, being contained but little more than once in the length of the scapula taken along the attachment of the spine. The supraspinous fossa in the Ochotonidæ is relatively much narrower, when compared with the infraspinous fossa, than it is in the Leporidæ.

The scapula of *Ochotona ladacensis* differs somewhat from that of the American species. The superior border is shorter and does not merge so gradually into the anterior border, so that the antero-superior angle is more pronounced.

#### HUMERUS

##### LEPORIDÆ

The humeri of the Leporidæ are all much alike in form and proportions, and the humeri of the Ochotonidæ differ but slightly from them in these respects. The variations in this bone in the different genera are few, hard to define, and apparently of little significance. They are as follows:

The groove that subtends the internal condyle is best marked in members of the genus *Lepus*. It is well marked also in *Sylvilagus*, *Oryctolagus*, and *Pronolagus*, but in *Limnolagus* and *Romerolagus* is much less developed and in *Pentalagus* it is very slight. *Brachylagus* occupies an intermediate position between these last two degrees of development. In *Pentalagus* the double trochlear surface at the distal extremity of the humerus differs from the same structure

in the other genera in having its two portions very unequally developed, the main one being very broad and shallow, and the external portion much reduced.

*Brachylagus* and *Romerolagus* have the slenderest humeri; *Oryctolagus* and especially *Pentalagus* have rather thick, heavy ones. All the other groups may be said to have moderately developed humeri.

The external condyloid ridge is very short and poorly developed in all the hares. *Romerolagus* has the most prominent external condyloid ridge; *Brachylagus* has a ridge as wide but not so long; *Limnolagus* has a short and comparatively wide ridge, but only a trifle more conspicuous than the ridge in *Sylvilagus* or in the other genera.

#### OCHOTONIDÆ

The humeri of the Ochotonidæ have a strong resemblance to those of the Leporidæ. The head of the bone is more globular in the former, the bicipital groove does not encroach on its anterior surface.

The tuberosities of the humeri of *Ochotona* bear about the same general proportions to one another that they do in the hares and rabbits. The greater tuberosity does not project so far upward in *Ochotona* as it does in the *Leporida*, so that the head of the humerus is the highest point of the bone, while in the hares and rabbits the greater tuberosity is the highest point.

When viewed from the side, the head of the humerus in the pikas is seen to project farther backward than in the hares, and to form a sort of hook with the shaft of the bone.

The double trachlear surface at the distal end of the humerus is shallow and wider in *Ochotona* than in any of the Leporidæ.

The groove subtending the internal condyle is rather shallow and inconspicuous in *Ochotona*; it is developed to about the same degree that it is in *Romerolagus*.

### RADIUS AND ULNA

#### LEPORIDÆ

(PLATE XCVIII, 1-10)

The bones of the forearm of the Leporidæ show some interesting differences among the various genera, in regard to their relative development and the length of the radius compared with the length of the humerus.

The radius and ulna are always perfectly distinct, but they are in contact with one another throughout the greater part of their extent. At the point of contact there is a certain amount of fusion, but at the same time each bone maintains its individual distinctness.



BONES OF THE FOREARM OF HARES, RABBITS, AND PIKAS (natural size)  
For explanation see page 447.



In the upper part of the forearm, the radius lies in front of the ulna, while at the distal extremity the radius is found toward the inner side.

The radius in general is flattened antero-posteriorly, presenting a rather flattened posterior surface and a convex anterior one. The upper extremity of the radius forms the inferior portion of the sigmoid notch for articulating with the double trachlear surface of the lower end of the humerus. The lower extremity of the radius is rather enlarged and its distal surface is concave, the concavity inclining to be double for articulating with the scaphoid and semilunar bones of the wrist.

The ulna in general lies behind the radius and toward the outer side. In some cases the shaft of the ulna is more heavily built than the shaft of the radius, while in other cases it is very much reduced. The outer part of the lower end of the ulna is prolonged downward into a convex articular surface which fits into a corresponding concavity formed jointly by the cuneiform and pisiform bones. This projecting part of the ulna is the only part of that bone which articulates with the carpus in the case of the Leporidae. In the case of the Ochotonidae, however, there is a concave facet internal to this projection which articulates with a corresponding convexity on the cuneiform. A condition approaching this is found in *Pentalagus*, *Romerolagus*, *Brachylagus*, and in some skeletons of *Sylvilagus* and *Lepus*.

In the genus *Lepus* the ulna is much reduced in size along the middle of the shaft, and except at the lower extremity it is placed almost entirely behind the radius. The radius itself is rather long and slender. The humerus and radius are usually subequal in length. In the subgenus *Macrotolagus*, at least so far as the limited material shows, the radius is slenderer than it is in the two other subgenera, *Lepus* and *Pacilolagus*, and it is decidedly longer than the humerus.

In the genera *Sylvilagus*, *Pronolagus*, and *Limnolagus* the radius and ulna are subequal in size, the ulna not being reduced in the middle part of the shaft. The ulna is situated external to the radius rather than behind it as in *Lepus*. Both radius and ulna as a rule are moderately slender. The radius equals the humerus in length.

The condition of the bones of the forearm in *Brachylagus* is very similar to that just described, but the humerus is distinctly longer than the radius.

In *Pentalagus*, in *Romerolagus*, and to a less extent in *Oryctolagus* the radius is slenderer than the ulna, except at the articular ends of the radius, where normal conditions exist. The humerus is distinctly longer than the radius, except in *Oryctolagus* where their lengths are subequal.

#### OCHOTONIDÆ

(PLATE XCVIII, 11)

In the Ochotonidæ the bones of the forearm resemble the ulna and radius of the Leporidæ in general form and position. The ulna is distinctly the larger of the two bones of the forearm throughout its whole extent. As noted in the description of that bone under the Leporidæ, the ulna has an extra facet at its distal surface for articulating with the carpus. The proximal articulating extremity of the radius maintains about the same relative size that it does in the Leporidæ, but the distal end is conspicuously reduced and the lower end of the ulna is correspondingly increased. The radius is distinctively shorter than the humerus.

#### CARPUS

##### LEPORIDÆ

(FIGURE 45, 1-3)

The full number of carpal bones (nine) is found in the Leporidæ. An understanding of their form and position is best obtained from consulting the figures. In all the skeletons the bones have the same relative shapes, sizes, and positions.

The pisiform is one of the largest carpal bones and has considerable dorso-palmar depth, except in *Pentalagus* where this depth is less and has about the same relative proportions that it has in *Ochotona*.

In the cuneiform, together with a small portion of the pisiform, is a cup-shaped depression into which fits the small rounded projecting head of the ulna. The internal and median portion of the proximal aspect of the cuneiform in most hares is scarcely at all developed, but in some of the skeletons (*Pentalagus*, *Romerolagus*, *Pronolagus*, *Brachylagus*, and rarely in *Sylvilagus* and *Lepus*) there is found internal to the cup-shaped cavity for the ulna, a small convex surface which articulates with the ulna internal to the projecting convexity.

The os centrale is a flask-shaped bone, only the neck of which appears in an undissected carpus. The distal aspect of the neck-like process articulates with the outer portion of the proximal end of the second metacarpal.



In some of the skeletons (and probably in all had they been carefully cleaned), in the angle between the unciform and the fifth meta-

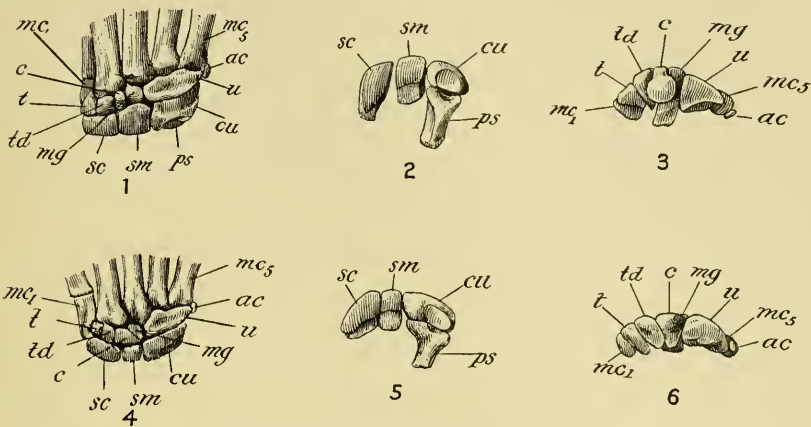


FIG. 45.—Carpus of the *Leporidae* and *Ochotonidae*. 1. Dorsal view of right carpus of *Sylvilagus floridanus mallurus*, No. 16,248, Carlisle, Pennsylvania, enlarged nearly twice. 2. Proximal view of proximal row of carpal bones of same. 3. Proximal view of distal row of carpal bones of same. 4. Dorsal view of right carpus of *Ochotona saxatilis*, No. 49,620, Oregon, enlarged nearly four times. 5. Proximal view of proximal row of carpal bones of same. 6. Proximal view of distal row of carpal bones of same. *ac*, accessory ossicle; *c*, os centrale; *cu*, cuneiform; *mc*<sub>1</sub>, first metacarpal; *mc*<sub>5</sub>, fifth metacarpal; *mg*, os magnum; *ps*, pisiform; *sc*, scaphoid; *sm*, semilunar; *t*, trapezium; *td*, trapezoid; *u*, unciform.

carpal, is a small bone which Forsyth Major calls the carpale 5. He regards the unciform as carpale 4 only, instead of the fused carpalia 4 and 5. This small bone is otherwise known as the os vesalianum.

#### OCHOTONIDÆ

(FIGURE 45, 4-6)

The carpus of the *Ochotonidae* differs in several respects from the carpus of the *Leporidae*. The pisiform has less dorso-palmar depth; the lunare is narrower; the internal half of the cuneiform is more largely developed, making up for the narrower lunare, and presents a well-developed convex facet for articulating with the ulna, in addition to the cup-shaped cavity formed by the cuneiform and pisiform jointly. The centrale is much larger than it is in the *Leporidae*, and is not flask-shaped. The os magnum is reduced in size. A small os vesalianum is present.

## METACARPUS

There are few points of interest about the metacarpus of either the Leporidae or the Ochotonidae; both have metacarpi of a generalized mammalian type. The first metacarpal is very short in both families. The fifth metacarpal is about twice or about two and a half times the length of the first. The middle metacarpal is the longest, but not much longer than the two subequal adjacent ones. The middle metacarpal is relatively longer in the Leporidae than in the Ochotonidae, with respect to the two metacarps on either side of it.

The metacarpus, as a whole, is longer in the Leporidae than it is in the Ochotonidae. The width of the three middle metacarps at their bases is contained about two and one-half times the length of the middle metacarpal in all the genera except *Pentalagus*. In the Ochotonidae, however, and in *Pentalagus* of the Leporidae the basal width of the three middle metacarps taken together is contained only about one and one-half times in the length of the middle metacarpal.

## PHALANGES

The phalanges are relatively longer in the Leporidae than in the Ochotonidae. In both families the length of the three phalanges of the middle digit about equals the length of the middle metacarpal, which bone, as noted above, is relatively longer in the hares and rabbits than in the pikas.

## OS INNOMINATUM

## LEPORIDÆ

The os innominatum in all the genera of the Leporidae is generally uniform in shape, differences being slight and apparently of not much importance, yet they are fairly constant for some genera or groups of genera.

In the genus *Lepus*, the ilium is broad and shovel-like; the antero-superior angle of the crest is rounded off, but not obliquely so as in the case of the other genera. The distance from the anterior edge of the acetabulum to the most anterior point of the ilium, is less than the distance from the same point to the most distant part of the ischium, while in all the other genera the distance from the anterior edge of the acetabulum to the most distant point of the ilium is equal to or a little greater than the distance measured from the same point to the most distant part of the ischium.

The obturator foramen is more rotund in *Lepus* than in most other genera.

In *Oryctolagus*, *Sylvilagus*, and *Brachylagus* the ossa innominata have about the same general form. There is nothing to distinguish these bones in the first two genera, but the innominate bone of *Brachylagus* can be distinguished by its smaller size and the greater prominence of the tubercle in front of the acetabulum and by a slenderer descending ramus of the pubis and shorter distance from the tuberosity of the ischium to nearest point of the obturator foramen. In the above three genera the ilium is not so wide and shovel-like as it is in *Lepus*. The anterior edge of the acetabulum is about equidistant between the extreme anterior and posterior points of the os innominatum, or just a little posterior to the equidistant point. The antero-superior angle of the ilium is obliquely rounded off. The thyroid foramen is usually less rotund than it is in *Lepus*.

The genus *Linnolagus* has wide ilia, much like those of *Lepus*, but the antero-superior angle is not obliquely rounded off. The antero-ventral angle is produced into a blunt, very short spine. The horizontal rami of the pubic bones slope backward more than they do in the other genera except *Romerolagus*.

The os innominatum of *Romerolagus* closely resembles that of *Linnolagus*. The only marked differences, aside from its slender formation, is the more pronounced development of the short, blunt spine at the antero-ventral angle, and the straightness of the ventral edge of the ilium. In all the other groups except the genus *Pronolagus* the ventral edge of the ilium has a more or less pronounced concavity on its posterior half.

The genus *Pronolagus* has an os innominatum resembling in most respects that of *Sylvilagus* and *Oryctolagus*, but the ilium is even narrower than it is in them. Its ventral edge is straight, in this respect being like the ventral edge of the ilium of *Romerolagus*.

#### OCHOTONIDÆ

The pelvis of the Ochotonidæ is very different from the pelvis of the Leporidæ. The most notable difference is the absence of the symphysis pubis. As none of the few available skeletons is sexed, it is impossible to say whether the difference is sexual or not. The pubic bones are widely separated from one another, but are connected by a ligament.

The os innominatum of the Ochotonidæ as a whole is longer and more slender than that bone in the Leporidæ. The ilium is less ex-

panded, thicker, its ventral third separated from the dorsal two-thirds by a well-marked ridge, which terminates anteriorly and ventrally in a well-marked, recurved, pointed spine. The tuberosity of the ischium is not so heavy and it lacks the processes seen in the Leporidae. The thyroid foramen is egg-shaped, the small end of the egg being directed forward toward the acetabulum.

The horizontal ramus of the pubis is very short, the descending ramus long, directed obliquely backward and downward.

## FEMUR

The femora in all the Leporidae resemble one another very closely. The bone is stout and heavy in *Pentalagus*, it is relatively thicker in *Oryctolagus* than in the remaining genera, and it is slenderest in *Brachylagus*, but individuals vary much in this respect. Of two *Lepus campestris*, one from Nebraska and the other from Kansas, one is relatively thicker than the other. The same individual variation is found in the series of skeletons of *Sylvilagus floridanus*. In most of the skeletons the femur is a little shorter than the tibia. In *Lepus (Macrotolagus) texianus*, however, it is decidedly shorter, in *Pentalagus* the two bones are subequal in length.

The femur in the Ochotonidae has the same general characteristics that it has in Leporidae, but it is a relatively thicker and heavier bone; the third trochanter is much reduced in size, the lesser trochanter is relatively larger, and the fossa behind the great trochanter is not so deep. Its length is a trifle less than that of the tibia.

## TIBIA AND FIBULA

(PLATE XCIX)

The tibia and fibula show about as few variations in the different groups of the Leporidae as do the femora. The fibula is a free, distinct bone above, but at a point somewhat above the middle of the tibia it becomes intimately fused with the bone and its identity is lost sight of from there on, in all the genera except *Romcrolagus* and *Pentalagus*, in which genera the fusion of fibula and tibia occurs at the middle of the latter bone. The point of fusion is highest in *Lepus*, next highest in *Sylvilagus*, *Oryctolagus*, *Pronolagus*, and *Limnolagus*, and in *Brachylagus* it is just above the middle point of the tibia. In *Pentalagus* the tibia and fibula are relatively much heavier than they are in the other genera. In *Romcrolagus* and *Limnolagus* also the tibia is relatively heavier than in the remaining



LEG BONES OF HARES, RABBITS, AND PIKAS (natural size). For explanation see page 447.



genera. In both *Romerolagus* and *Limnolagus*, especially the former, the tibia is more curved than it is in the other rabbits, the inner surface of the lower part of the shaft of the tibia being concave, as it is in *Ochotona*.

In most of the skeletons the greatest length of the foot is about equal to the length of the tibia. In *Brachylagus* and *Sylvilagus floridanus* subsp. No. 94,197, from Nevada, the foot is longer than the tibia. In the subgenus *Macrotolagus* and in the genus *Romerolagus* the foot is shorter than the tibia.

The tibia and fibula in the Ochotonidæ are similar in form to the same bones in *Romerolagus*.

## TARSUS

(PLATE C)

The tarsal bones in all the skeletons show few differences among the Leporidæ, except as to size. The middle cuneiform is not fused to the base of the second metatarsal.

The tarsus of the Ochotonidæ is in general like that of the Leporidæ. The middle cuneiform, however, is entirely fused with the base of the second metatarsal. The foot, as a whole, is relatively shorter than it is in the Leporidæ.

In the Ochotonidæ there are some small sesamoid bones, on the plantar surface of the tarsus, which are apparently lacking in the feet of the Leporidæ. These bones are discussed by Major at considerable length. Their true significance and functions cannot be well determined without the dissection of fresh material. The largest of these sesamoid bones is situated on the plantar surface of the base of the fifth metatarsal. In the Leporidæ this bone seems to have become fused with the base of the fifth metatarsal, where it forms a prominent tubercle.

## METATARSUS

The metatarsals in both the Leporidæ and the Ochotonidæ are four in number, the first being suppressed. According to their relative lengths the metatarsi in the two families fall into four groups, as follows: The basal width of the metatarsus, measured from the tuberosity of the fifth to an opposite point on the second is contained about three times in the length of the third metatarsal in *Lepus*. It is contained about two and a half times in *Sylvilagus*, *Oryctolagus*, *Limnolagus*, *Brachylagus*, and *Pronolagus*. It is contained two times in *Romerolagus*. In *Pentalagus* and *Ochotona* it is contained one and a half times.

## PHALANGES

Little can be said regarding the toes. The two lateral digits are relatively longer in the Ochotonidæ than they are in Leporidæ. In *Ochotona*, *Romerolagus*, *Pronolagus*, *Limnolagus*, *Oryctolagus*, and *Brachylagus* the combined lengths of the three phalanges approximately equals the length of the metatarsal to which they belong. In the other genera, *Lepus* and *Sylvilagus*, this is true of the middle digits only; in the case of the lateral digits the metatarsals are decidedly longer than the combined length of the corresponding phalanges.

## V. OSTEOLOGICAL DIFFERENCES BETWEEN OCHOTONIDÆ AND LEPORIDÆ

The principal osteological differences between the two families Ochotonidæ and Leporidæ, discussed in the foregoing pages, are briefly set forth in the following table:

OCHOTONIDÆ	<i>Skull</i>	LEPORIDÆ
Not arched, flat, much constricted between the orbits.		More or less arched, not flat, only moderately constricted between the orbits.
Rostrum short and slender.		Rostrum long and stout.
Nasals widest in front.		Nasals not wider in front than behind.
Palate very short.		Palate moderately short.
Postorbital processes lacking.		Postorbital processes well developed.
Posterior free edge of malar very long.		Posterior free edge of malar only moderately long.
Maxilla not conspicuously fenestrated.		Maxilla more or less conspicuously fenestrated.
Mental foramen of mandible far posterior to its usual position.		Mental foramen of mandible anterior, in its usual position.
	<i>Teeth</i>	
Dental formula		Dental formula
$I \frac{2}{1} C \frac{0}{0} Pm \frac{3}{3} M \frac{3}{3}$		$I \frac{2}{1} C \frac{0}{0} Pm \frac{3}{3} M \frac{3}{3}$
Enamel not crenated in reentrant angles of upper cheek teeth.		(In one genus, <i>Pentalagus</i> , $M \frac{2}{3}$ ). Enamel usually crenated in reentrant angles of upper cheek teeth.
Cutting edge of first upper incisor V-shaped.		Cutting edge of first upper incisor straight.
Third upper molar entirely wanting.		Third upper molar small but usually present (absent in <i>Pentalagus</i> only).
Second and fifth upper cheek teeth unlike third.		Second and fifth upper cheek teeth entirely similar to third.
Last lower molar simple.		Last lower molar double.





HIND FEET OF HARES, RABBITS, AND PIKAS (natural size). For explanation see page 447.



*Vertebral Column*

Transverse process of the seventh cervical not pierced by a vertebral foramen.

Thoracic vertebræ seventeen in number.

Thoraco-lumbar vertebræ twenty-two in number.

Spinous processes of thoracic vertebræ relatively short.

Spinous processes of lumbar vertebræ relatively low.

Transverse processes of lumbar vertebræ very short and wide.

No hypophyses on any of the lumbar vertebræ.

Sacrum long and narrow, twice as long as wide.

Transverse process of the seventh cervical pierced by a vertebral foramen.

Thoracic vertebræ twelve in number.

Thoraco-lumbar vertebræ nineteen in number.

Spinous processes of thoracic vertebræ relatively long.

Spinous processes of lumbar vertebræ relatively high.

Transverse processes of lumbar vertebræ long and slender.

Hypophyses found on the anterior three lumbar vertebræ.

Sacrum wide and triangular about as wide as long.

*Shoulder Girdle and Upper Extremity*

Clavicle well developed.

Scapula with antero-superior angle much rounded off.

Acromion very long, three times the length of actual scapular spine.

Supraspinous fossa of scapula narrow.

Dorso-palmar depth of pisiform not pronounced.

Internal half of cuneiform more largely developed, presenting a well developed convex facet for articulation with the ulna, in addition to the cup-shaped cavity formed by the cuneiform and pisiform together.

Centrale larger, not flask-shaped.

Os magnum smaller.

Width of three middle metacarpals at base contained about one and a half times into length of the middle metacarpal.

Clavicle small and rudimentary.

Scapula with antero-superior angle not much rounded off.

Acromion long, about half the length of the actual scapular spine.

Supraspinous fossa of scapula much wider.

Dorso-palmar depth of pisiform very great, except in *Pentalagus*.

Internal half of cuneiform not largely developed nor presenting a well developed convex facet for articulation with the ulna, though sometimes such a condition is indicated.

Centrale smaller, flask-shaped.

Os magnum larger.

Width of three middle metacarpals at base contained about two and a half times into length of the middle metacarpal, except in *Pentalagus*.

*Pelvis and Lower Extremity*

Pubic symphysis absent.

Antero-ventral angle of ilium with a well-marked recurved spine.

Middle cuneiform bone of the foot intimately fused with the base of the second metatarsal.

Basal width of the metatarsals taken together contained less than twice into the length of the metatarsals.

A large sesamoid bone on the plantar surface of the fifth metatarsal.

Pubic symphysis well marked.

Antero-ventral angle of ilium without a well-marked recurved spine.

Middle cuneiform of foot not fused with the base of the second metatarsal.

Basal width of the metatarsals contained two or more times into the length of the metatarsals, except in *Pentalagus* one and a half times.

A prominent tubercle on the base of the plantar surface of the fifth metatarsal.

VI. KEYS TO FAMILIES, GENERA, AND SUBGENERA OF THE  
DUPLICIDENTATA, BASED ON DENTAL, CRANIAL,  
AND OTHER SKELETAL CHARACTERS

A. KEY TO THE FAMILIES AND GENERA OF EXISTING HARES, RABBITS, AND  
PIKAS, BASED MAINLY ON DENTAL CHARACTERS

- a) Dental formula:  $I \frac{2}{1}$ ,  $C \frac{0}{0}$ ,  $Pm \frac{3}{3}$ ,  $M \frac{2}{2}$ , second upper molariform tooth unlike third in form. Family OCHOTONIDÆ, genus *Ochotona*, p. 431.
- a') Dental formula usually  $I \frac{2}{1}$ ,  $C \frac{0}{0}$ ,  $Pm \frac{3}{3}$ ,  $M \frac{3}{3}$  (in *Pentalagus* the molars are  $\frac{2}{2}$ ), second upper maxillary tooth like third in form. Family, LEPORIDÆ, p. 389.
- b) Reentrant angle of second upper maxillary tooth short and not crenated.
- c) Reentrant angle extends one-third way across the tooth, genus *Nesolagus*, p. 425.
- c') Reentrant angle extends half way across the maxillary teeth, genus *Brachylagus*, p. 411.
- b') Reentrant angles of second, third, fourth, and fifth maxillary teeth with sides crenated.
- d) First lower premolar divided into an anterior and a posterior portion by two reentrant angles, one extending from the external, the other from the internal face to the center of the tooth.
- e) Anterior face of first lower premolar without reentrant angles. Genus *Romerolagus*, p. 420.
- e') Anterior face of first lower premolar with two reentrant angles.
- f) Posterior limb of reentrant angles of second, third, and fourth mandibular cheek teeth with antero-posterior convolutions nearly as long as the antero-posterior diameter of the posterior portions of the teeth. Genus *Pentalagus*, p. 428.
- f') Posterior limb of reentrant angles of second, third, and fourth mandibular cheek teeth with normal convolutions, not nearly so long as the antero-posterior diameter of the posterior portions of the teeth. Genus *Pronolagus*, p. 416.
- d') First lower premolar divided into an anterior and posterior portion by a single deep reentrant angle extending entirely across the tooth from its external surface.
- g) First lower premolar with but one reentrant angle on its anterior face. (Some Mexican *Sylvilagus* have two.)
- h) Sutures of the interparietal obliterated in the adult, genus *Lepus*, p. 389.
- i) Groove on incisors not filled with cement. Subgenus *Pacilolagus*, p. 395. Also some *Lepus* and *Macrotolagus*.
- i') Groove on incisors filled with cement.
- j) Groove deep and simple. Mostly subgenus *Lepus*, p. 394.
- j') Groove deep and bi- or tri-furcated. Mostly subgenus *Macrotolagus*, p. 395.

- h') Sutures of the interparietal distinct throughout life.
- k) Choanæ narrow. Genus *Oryctolagus*, p. 402.
- k') Choanæ not narrowed. Genus *Sylvilagus*, p. 396.
- g') First lower premolar with two crenated reentrant angles on its anterior face.
  - l) Internal face of anterior portion of first lower premolar without reentrant angle. Genus *Limnolagus*, p. 406.
  - l') Internal face of anterior portion of first lower premolar with reentrant angle. Genus *Caprolagus*, p. 426.

B. KEY TO THE FAMILIES, GENERA, AND SUBGENERA OF EXISTING HARES, RABBITS, AND PIKAS, BASED ON CRANIAL CHARACTERS

- a) Postorbital process absent, skull flat, much constricted between orbits, rostrum short and slender, nasals widest in front, bony palate very short, posterior free edge of malar very long, maxilla not conspicuously fenestrated, mental foramen of mandible situated under last lower molar. Family OCHOTONIDÆ, genus *Ochotona*, p. 431.
  - b) Interorbital region very narrow and pinched up and strongly arched from before backward. Subgenus *Ochotona*, p. 438.
  - b') Interorbital region moderately broad, not compressed laterally nor arched from before backward.
    - c) Brain case and whole skull very flat, rostrum slender, its origin abrupt, no foramen in the anterior part of the frontal bone. Opening in maxilla single, roundly triangular. Incisive foramina constricted into two unequal portions. Subgenus *Pika*, p. 438.
    - c') Brain case rather rounded, whole skull moderately arched from before backward, rostrum relatively long and heavy, its origin not abrupt, a small oval foramen in frontal bone. Opening in maxilla elongated triangular with a small amount of fenestration just beneath it. Incisive foramina triangular in outline, not constricted into two unequal portions. Subgenus *Conothoa*, p. 438.
- a') Postorbital process well developed, skull arched from before backward, moderately constricted between the orbits, bony palate only moderately short, rostrum long and stout, nasals widest behind, posterior free edge of malar only moderately long, sides of maxilla more or less conspicuously fenestrated, mental foramen of mandible situated under first lower cheek tooth. Family LEPORIDÆ.
  - d) Postorbital process attached to the side of the skull for its whole length. Genus *Limnolagus*, p. 406.
  - d') Postorbital process not attached to the side of the skull for its whole length, bounding well marked foramina or notches.
    - e) Postorbital process small, without anterior limb, the single posterior limb pointed, directed outward and backward, bounding a distinct notch. Bony palate long.
    - f) Nasals relatively short, as broad in front as behind.
      - g) Incisive foramina elongated triangle in outline, postorbital process smaller and pointed. Genus *Caprolagus*, p. 426.

- g') Incisive foramina, not triangular in outline, small, their sides approximately parallel, postorbital process larger and blunter. Genus *Pentalagus*, p. 428.
- f') Nasals relatively larger, wider behind than in front.
- h) Audital bulla much reduced in size, smaller than foramen magnum. Genus *Pronolagus*, p. 416.
- h') Audital bulla normal, as large as the foramen magnum. Genus *Romcrolagus*, p. 420.
- c') Postorbital process large with distinct anterior and posterior limbs, bony palate relatively shorter, usually less than its posterior third formed by the horizontal plates of the palate bones.
- i) Interparietal not present as a distinct bone in adult life. Genus *Lepus*, p. 389.
- j) Skull shortened and arched, posterior limb of postorbital not touching the sides of the cranium.
- k) Size large, postorbital process wide and heavy, nasals and rostrum wider and heavier. Spines of lumbar vertebrae well marked. Subgenus *Lepus*, p. 394.
- k') Size medium, postorbital process rather slenderer, nasals and rostrum narrower. Spines of lumbar vertebrae low and triangular. Subgenus *Pacilolagus*, p. 395.
- j') Skull elongated, less arched, posterior limb of postorbital meeting side of cranium and enclosing a large foramen. Subgenus *Macrotolagus*, p. 395.
- i') Interparietal present as a distinct bone in adult life.
- l) Choanae very narrow, pharyngeal vault high, distance between vertical plates of palate bones less than least length of bony palate. Posterior limb of postorbital not meeting side of skull. Genus *Oryctolagus*, p. 402.
- l') Choanae not remarkably narrow, the distance between the vertical plate of palate bones equal to or greater than the least length of bony plate.
- m) Skull and rostrum shortened, arched, audital bullae very large. Postorbitals slender, neither its anterior nor its posterior limb touches the side of the skull. Genus *Brachylagus*, p. 411.
- m') Skull and rostrum not relatively shortened, audital bullae not greatly enlarged, posterior limb of postorbital usually in contact with side of the cranium, rostrum heavier. Genus *Sylvilagus*, p. 396.
- n) Posterior limb of postorbital always meeting side of cranium, and enclosing a clavate slit narrower than the process itself. Subgenus *Sylvilagus*, p. 401.
- n') Posterior limb of postorbital not meeting the side of the cranium, or if it does, enclosing a clavate slit as wide or wider than the process itself. Rostrum slenderer. Subgenus *Microlagus*, p. 402.

C. KEY TO THE FAMILIES AND GENERA OF HARES, RABBITS, AND PIKAS, BASED ON SKELETAL CHARACTERS OTHER THAN CRANIAL

(Because of insufficient material, the genera *Caprolagus*, *Pentalagus*, and *Nesolagus* can not be incorporated in this key.)

- a') Transverse process of 7th cervical vertebra, with no vertebral foramen, thoracic vertebræ 17, lumbar vertebræ 5, sacrum much longer than wide. Acromion about 3 times the length of actual scapular spine, foot short, basal width of metatarsals contained  $1\frac{1}{2}$  times into length of longest metatarsal. Family OCHOTONIDÆ. Genus *Ochotona*, p. 431.
- a) Transverse process of 7th cervical vertebra, with no vertebral foramen, thoracic vertebræ 12, lumbar 5, sacrum as wide as long. Acromion process about half the length of the actual scapular spine, foot long, basal width of metatarsals contained at least 2 times and usually  $2\frac{1}{2}$  times into the length of longest metatarsal. Family LEPORIDÆ.
- b) Cervical vertebræ lengthened individually, ulna much reduced in size, smaller than radius and behind that bone, ventral half of anterior ribs much broadened. Genus *Lepus*, p. 394.
- b') Cervical vertebræ individually shortened, ulna and radius subequal in size, the ulna toward the outer side of radius. Ventral half of anterior ribs not broadened.
- c) Transverse processes of the lumbar vertebræ not conspicuously ridged, and the angle between the process and the side of the centrum not conspicuously filled in with thin bone.
- d) Tubercles of anterior ribs not well marked. Genus *Pronolagus*, p. 416.
- d') Tubercles of anterior ribs usually well marked.
- e) Presternum with well marked keel, xiphisternum large and stout, equally enlarged at both ends, longer than presternum. Genus *Oryctolagus*, p. 402.
- e') Presternum with keel not well marked, xiphisternum shorter than presternum. Genus *Sylvilagus*, p. 396.
- c') Transverse processes of lumbar vertebræ conspicuously ridged or else angle between the process and the side of centrum conspicuously filled in with thin bone.
- f') Anterior portion of presternum conspicuously enlarged, like presternum of *Ochotona*. Genus *Romerolagus*, p. 420.
- f) Anterior portion of presternum not conspicuously enlarged.
- g) Size small, each transverse process of the lumbar vertebræ with a well marked longitudinal ridge. Genus *Brachylagus*, p. 411.
- g') Size larger, angle between transverse process and side of centrum of lumbar vertebræ filled in with thin bone. Genus *Linnolagus*, p. 406.

VII. DETAILED ACCOUNT OF THE GENERA AND SUB-GENERA OF THE EXISTING HARES, RABBITS, AND PIKAS

FAMILY LEPORIDÆ

Genus **LEPUS** Linnæus

1758. *Lepus* LINNÆUS, Syst. Nat., 10th ed., 1, p. 57.

1829. *Chionobates* KAUP, Entw. Gesch. und Natur. Syst. Europ. Thierwelt, 1, p. 170.

1867. *Lepus* GRAY, Ann. Mag. Nat. Hist., XX, 3d ser., p. 222.

1900. *Lepus* MAJOR, Trans. Linn. Soc. London, 3d ser., VIII, Zool., p. 514, November, 1899.

*Type*.—*Lepus timidus* Linnæus.

*Geographical Distribution*.—The genus *Lepus* is found throughout nearly every portion of the world except Australia, Madagascar, and South America.

*Diagnosis*.—Pelage soft, a patch on throat different in color and texture from surrounding fur, ears as long as or longer than head, tail short but plainly evident. Hind feet long, heavily clothed with hair, claws not conspicuous. Sutures of interparietal obliterated in the adult, postorbital processes large and triangular, with distinct anterior and posterior limbs. Palate short, its least length two and one-half or less times the length of  $M^1$ , choanæ wide, about four times length of  $M^1$ . Teeth normal as described on page 391.

*Skull* (pls. LXXIV, LXXV, LXXX–LXXXV).—The postorbital processes are large and spreading, usually distinctly triangular, standing out from the side of the head and considerably arched from before backward.

The sutures of the interparietal are obliterated at an early age, so that in adult life the interparietal is not distinguishable as a separate bone. Apparently the only other genera of the Leporidae in which this condition occurs are *Pronolagus* and *Pentalagus*.

The bony palate is very short, but not relatively so short as it is in *Brachylagus*. The horizontal plates of the palate bones form between a fourth and a third of the bony palate. The posterior portion of the palate bone, bordering the edge of the maxilla, caudad of the posterior edge of the bony palate, is very slightly developed and scarcely enters into the formation of the roof of the mouth.

The posterior palatine foramina are of moderate size and located between the palatine plate of the maxilla and the horizontal plate of the palate bone, at the anterior outer angle of the horizontal plate.

As in *Brachylagus*, the choanæ are wide in the genus *Lepus*. The length of the bony palate, taken at a point midway between the median line and the dental alveoli, is decidedly less than the least distance between the vertical plates of the palate bones.

The incisive foramina are wide; their greatest width much exceeds the length of the bony palate, measured midway between the median line and the dental alveoli.

The zygoma is deep, but not thickened. The foot-like extremity of the zygomatic process of the squamosal is shorter in *Lepus* than



in most of the other genera. The external lateral length of the squamoso-malar suture is contained about twice in the superior border of the zygoma, measured from the anterior end of the squamoso-malar suture to the antero-inferior angle of the orbit. The antero-inferior angle of the zygoma is only slightly enlarged in *Lepus*. The posterior free projecting extremity of the malar is short.

The audital bullæ, the fenestration of the maxillæ, and the shape of the mandible throughout the genus show nothing distinctive and may be said to represent normal degrees of development.

*Teeth* (pl. xci, 6).—The following are the dental characters of the genus *Lepus*: Front upper incisor with longitudinal groove in anterior face, more or less deep, simple or branched internally, filled or unfilled with cement. First upper maxillary tooth has typical folding of enamel on the anterior surface, a deep median reentrant angle, on either side of which is a smaller reentrant angle. The first lower molariform tooth, divided into two portions by a single reentrant angle from the external face, has a small reentrant angle on its anterior surface, and a shallow broader reentrant angle on the external surface of the anterior half of the tooth. The second, third, fourth, and fifth upper molariform teeth show each a deep reentrant angle extending from the internal face about three-quarters the distance across the tooth; the adjacent edges of this angle are almost in contact with one another throughout their whole extent. The enamel of the reentrant angles is beautifully crenated. The lateral diameter of the posterior half of each of the second, third, and fourth lower molariform teeth is about four-fifths the lateral diameter of the anterior half of the tooth. The last upper molar is a small elliptic cylinder; the last lower molar is a small double cylinder in form, the anterior half of which is larger and elliptical, the posterior half terete.

*Vertebral Column*.—The cervical vertebræ (pl. xcii, 7-9) of *Lepus* have a form characteristic for the genus and are uniformly lengthened as compared with the same series of vertebræ in the other genera. The costo-transverse process does not project laterally from the centrum to a marked extent, and the anterior and posterior spines of the same are more elongated.

The thoracic vertebræ show practically nothing characteristic of *Lepus*. The neural spines in the anterior part of the series equal about two and a half to three times the length of their centra. The anticlinal vertebra is usually the eleventh, but it may be the tenth. A well-developed metapophysis is found on the ninth thoracic.

The lumbar vertebræ (pl. XCIII, 1, 2) have transverse processes peculiar to this genus. They are wide and long with the free extremity considerably expanded. The length of the longest process equals the length of the centrum to which it is attached and half the length of the centrum in front. The attached portion of the transverse process arises abruptly from the anterior half of the side of the centrum. The anapophyses are indicated by a mere ridge or tubercle. Hypophyses are developed on the first three lumbar, the first being the shortest and the third the longest.

Except in absolute size the sacra in all the skeletons but one differ in no respect from the sacra of the other genera. The single exception is No. 49,621, from the Jumna river, India. The narrow posterior part of this sacrum is very narrow from side to side. The expanded wing-like portion to which the ilia are attached is very narrow. In general its shape, as seen from below, is like a T. The adjacent edges of the first and third, and of the third and fourth sacral neural processes are in contact.

The total number of caudal vertebræ varies from thirteen to fifteen; of these the first is long and with a complete neural arch, the next five or seven, usually seven, are of the form having more or less evident broad transverse processes, the remaining five to seven are small rudimentary centra, without processes.

*Sternum and Ribs* (pls. xciv, 1, 2; xcv, 3, 4).—The sternum of the genus *Lepus* is not very characteristic. The presternum is long and narrow, compressed laterally into a keel, which is most prominent anteriorly. The first rib articulates with it at the junction of the first and second fourths, or first and second thirds. The mesosternum consists of four distinct segments, of which the first is narrow and compressed, the remaining three are not compressed, and are often flattened dorso-ventrally. All the mesosternal segments in general are subequal in length, and each successive one grows wider. The xiphisternum is about equal to the presternum in length; its anterior end is considerably enlarged where it articulates with the last segment of the mesosternum. Its posterior free extremity is rather pointed and only slightly larger than its narrowest portion.

The form of the ribs is quite characteristic for the genus *Lepus*. The spine-like portions of the tubercles of the ribs are well developed and prominent. The eighth pair of ribs is the last pair bearing these tubercles. The second, third, fourth, and fifth ribs are very flat and broad on the ventral half of their shafts. The greatest width of one of these ribs, just behind the spine and tubercles, is very much less than the width of the shaft in its lower portion. Seven pairs of ribs

articulate with the sternum. The sternal costal cartilages are very short and wide as compared with the same structures in the other genera.

*Shoulder Girdle and Upper Extremity.*—The scapula (pl. xcvii, 1, 2) in *Lepus*, especially in the larger members, has a tendency to be relatively broad, with the superior border rather more convex than it is in the other genera, with the antero-superior angle more rounded, and with the supra-spinous fossa relatively wide.

The radius and ulna (pl. xcvi, 1-3) show characteristics peculiar to the genus. The ulna is much reduced in size along the middle of the shaft, and except at the lower extremity it is placed almost entirely behind the radius. The radius itself is rather long and slender. The humerus and radius are usually subequal in length.

The carpus, the metacarpus, and the phalanges of *Lepus* are entirely similar in form and position to these same bones in any of the Leporidae as detailed in the general account of the wrist and the hand.

*Pelvis and Lower Extremity.*—The ilium is broad and shovel-like in the genus *Lepus*; its antero-superior angle is rounded off, but not obliquely so, as in the case of the other genera. The distance from the anterior edge of the acetabulum to the extreme anterior point of the ilium is less than the distance from the former point to the most distant point of the ischium. In all the other genera the former distance is usually equal to or a little greater than the latter. The obturator foramen is usually more rotund in *Lepus* than in the rest of the family.

The femur and the tibia and fibula (pl. xcix, 1) of *Lepus* are typical for the family, as detailed in the general account and show nothing that is peculiar to the genus.

The basal width of the metatarsus is contained two and a half or more often three times into the length of the third metatarsal, as is commonly the case among the Leporidae (pl. c, 6).

The combined length of the phalanges of the two lateral digits is less than the length of the metatarsal to which they belong. The combined length of the phalanges of the middle two digits approximately equals the lengths of the metatarsals to which they belong.

The genus *Lepus* possesses a number of skeletal characters quite peculiar to itself and serving to separate it at once from all the other genera of the Leporidae. Among these are form of postorbital processes, shortness of palate, reduced size of ulna, shape of anterior ribs, shape of transverse processes of lumbar vertebræ, and the elongated form of the cervical vertebræ. Not one of these charac-

ters is found in any of the other genera. To these might also be added the obliteration of the sutures of the interparietal in the adult, which is nearly as characteristic.

Thus there is considerable foundation for Major's view that the existing hares and rabbits fall into two supergeneric groups, one containing *Lepus*, and one containing the other genera, which he designates as *Caprolagus*. It is the writer's opinion, however, that Major's group, *Caprolagus*, contains many genera as well defined as *Lepus*.

The genus *Lepus* has the most extensive geographic distribution and the greatest number of species of any of the Leporidae. As would be expected, there are several groups of these species, constituting at least three well-marked subgenera for forms from North America and northern Eurasia described below. There are a number of skulls at hand, however, from central and eastern Asia and from Africa, which it is impossible to classify satisfactorily, owing to lack of material, and no provision is made for these in the present discussion. For a list of these specimens see page 335.

#### Subgenus **LEPUS** Linnæus

1758. *Lepus* LINNÆUS, Syst. Nat., 10th ed., I, p. 57.

1900. *Lepus* MAJOR, Trans. Linn. Soc. London, 2d ser., VIII, Zool., p. 514, November, 1899.

*Type*.—*Lepus timidus* LINNÆUS.

*Geographical Distribution*.—Mainly the northern portions of the New and Old Worlds.

*Diagnosis*.—Size large, ears moderate, greatest length of skull nearly 100 mm.; skull broad, postorbital broader than notch it subtends, its posterior limb not touching side of cranium.

The skull is broad and strongly arched. The rostrum is shorter and broader and the brain case is broader and the nasals shorter and broader than they are in the other members of the genus *Lepus*. The postorbital processes are broad and triangular, neither the anterior nor the posterior limbs touch the sides of the cranium, but help to bound well-marked anterior and posterior notches.

*Tecth* (figure 44, 19-21).—The groove on the front of the incisors is fairly deep, is simple and usually filled with cement.

This subgenus apparently possesses no other skeletal character. Species included in this subgenus, see p. 334.

**Subgenus PÆCILOLAGUS, new**

*Type*.—*Lepus americanus* ERXLEBEN.

*Geographical Distribution*.—The Canadian, Hudsonian, and Transition zones of North America.

*Diagnosis*.—External, cranial, and dental characters essentially as in subgenus *Lepus*, but size smaller, greatest length of skull about 75 mm., portorbital process slenderer than in *Lepus*, its posterior limb free behind, rostrum more pointed, groove on incisors simple, shallow, and without cement. Spinous processes of lumbar vertebræ low and triangular in form.

*Skull* (pls. LXXV, 1; LXXVI, 1, 4; LXXXIV; LXXXV, 6–12).—The members of this subgenus are hares of medium size, the skull being about 75 mm. long. The skull is less strongly arched than it is in the true *Lepus*, but not so flat and long as in *Macrotolagus*. The nasals and rostrum are narrower than they are in *Lepus*. The postorbital processes are much slenderer, less triangular than they are in *Lepus* or *Macrotolagus*, free both in front and behind. They bear considerable resemblance to the postorbital seen in *Oryctolagus*.

*Teeth* (figure 44, 18).—The first upper incisors bear each a simple shallow groove not filled with cement. The remaining teeth are as in true *Lepus*.

*Vertebral Column*.—The spines of the anterior dorsal vertebræ are relatively shorter than they are in true *Lepus*, being equal to about two and a half times the length of the centra, instead of three times. The spinous processes of the lumbar vertebræ (pl. XCIII, 2) are also relatively lower in *Pæcilolagus* than in *Lepus*: they are triangular in outline, with the posterior edge nearly straight, while in the other subgenera the posterior edge is much cut out.

Species included in this subgenus, see pp. 334 and 335.

**Subgenus MACROTOLAGUS Mearns**

1896. *Macrotolagus* MEARNS, Proc. U. S. Nat. Mus., XVIII, p. 552, June 24, 1896.

1899. *Macrotolagus* MAJOR, Trans. Linn. Soc. London, 2d ser., VII, Zool., pp. 468, 469, November, 1899.

*Type*.—*Lepus alleni* MEARNS.

*Geographical Distribution*.—Mexico and the southwestern United States.

*Diagnosis*.—Size large, as in subgenus *Lepus*, ears longer than head or hind foot, skull narrow, posterior limb of postorbital touching side of cranium, enclosing an oval foramen.

*Skull* (pls. LXXIV, 1; LXXV, 2; LXXXII; LXXXIII).—The skull of *Macrotolagus* is large and slender. It is not arched as in the subgenus *Lepus*. The nasals are larger and narrower, the brain case is narrower, and the choanæ somewhat narrower. The postorbital processes are larger, rather longer than they are in the true *Lepus*, and their posterior angles are always attached to the side of the cranium enclosing large foramina.

*Teeth* (figure 44, 11–17).—The groove on the front of the incisor teeth in this subgenus may be perfectly simple and not filled with cement as it is in *Lepus* (*Macrotolagus*) *californius*, but more often it is deep and filled with cement as in *L. (M.) texianus*, where the groove is simple, and in *gaillardi*, *alleni*, *merriami*, where the groove is bifurcated internally, and in *callotis* and *asellus* where the groove is trifurcated internally. This is the only group of the Leporidae in North America that shows this complicated folding of the groove internally, but at the same time some members of it do not show it. When found in a North American rabbit this folding of the groove on the incisor is diagnostic of the subgenus, but when not found it is without significance.

*Vertebral Column*.—The length of the neural spines is a little greater than it is in either the subgenus *Lepus* or *Pacilolagus*. In the latter two it is about three times the length of the centrum in the anterior part of the thoracic series of vertebræ; in *Macrotolagus* it is a little over three times the length of the centrum.

*Upper Extremity* (pl. XCVIII, 2).—The radius is slenderer than in the other members of the genus *Lepus* and longer than the humerus, while in the other subgenera, the humerus and radius are about equal in length.

Species belonging to this subgenus, see p. 335.

#### Genus SYLVILAGUS Gray

1867. *Sylvilagus* GRAY, Ann. Mag. Nat. Hist., XX, 3d ser., p. 221.

1896. *Sylvilagus* MEARNS, Proc. U. S. Nat. Mus., XVIII, p. 551, June 24, 1896.

1899. *Sylvilagus* MAJOR, Trans. Linn. Soc. London, 2d ser., VII, Zool., p. 514, November, 1899.

*Type*.—*Sylvilagus floridanus mallurus* (THOMAS).

*Geographical Distribution*.—In general, North America south of the northern border of the United States and in South America.

*Diagnosis*.—External and dental characters as in *Lepus*. Skull essentially like that of *Lepus* except that sutures of interparietal are always distinct; the postorbital process is long and narrow, its

posterior limb touching the side of the cranium and helping to bound a clavate foramen. Rarely the process fails to meet the cranium.

*Skull* (pls. LXVI, 7-10; LXVII, 1, 2; LXXXVI; LXXXVII).—The postorbital processes are long and narrow, attached to the skull by a very broad pedicle. The whole anterior part of the process, with the exception of a millimeter or two, is attached to the skull and a very small anterior notch is thus formed. The posterior part of the postorbital process is long and narrow, not triangular. Its inner posterior edge usually touches the cranium and the process thus forms a narrow clavate slit. The amount of fusion of the postorbital process is subject to considerable variation. In one individual, *Sylvilagus floridanus mearnsi*, from Illinois, complete fusion of the postorbital with the side of the skull takes place and the usual clavate slit is obliterated. In *Sylvilagus arizonæ* and its forms the anterior portion of the postorbital process is not so extensively fused with the frontal bone and a larger anterior notch is found than in the more typical forms. In the most highly differentiated forms of the subgenus *Microlagus*, viz., *bachmani*, the postorbital process is attached by a comparatively narrow pedicle, a large notch is found in front, and as the posterior end of the postorbital does not meet with the cranium a large notch is found posteriorly instead of the usual clavate slit. In No. 63,957, *Sylvilagus bachmani*, from Posts, California, the posterior extremity of the postorbital almost touches the cranium. Skulls of *S. (Microlagus) cinerascens* show conditions ranging from those seen in No. 63,957 to conditions very similar to those found in typical *Sylvilagus*, but the posterior clavate slit is always relatively wider. Intermediate conditions are thus found from the extreme freedom of the postorbital seen in *S. bachmani*, No. 35,131, Nicasio, California, passing through *S. cinerascens* and then *S. arizonæ* and normal typical *Sylvilagus*, to the atypical skull, from Illinois, No. 22,409, where the postorbitals are entirely fused to the sides of the cranium.

The bony palate in true *Sylvilagus* is rather short, slightly larger relatively than it is in *Lepus* or *Brachylagus*, but shorter than in any of the other genera. Its length half-way between the median line and the dental alveoli about equals the greatest width of the incisive foramina and also the distance between the vertical plates of the palate bones. In the *Sylvilagus arizonæ* group the palate is shorter than in typical *Sylvilagus*; its length half-way between the median line and the dental alveoli is less than the width of the incisive foramina and about equals the distance between the vertical plates of the palate bones, which are here closer together than in

any of the rabbits except those of the genus *Oryctolagus*. The portion of the palate bone that borders the maxilla caudad of the posterior edge of the bony palate is poorly developed in *Sylvilagus*.

The posterior palatine foramina are of moderate size and located between the palatine plate of the maxilla and the horizontal plate of the palate bone, at the anterior outer angles of the horizontal plate.

The zygoma of *Sylvilagus* is thin and shallow. The foot-like extremity of zygomatic process of the squamosal is short, the external lateral length of the squamoso-malar suture is contained about two times into the superior border of the malar measured from the anterior end of the squamoso-malar suture to the antero-inferior angle of the orbit. The antero-inferior end of the zygoma is only slightly enlarged. The posterior free extremity of the malar is short.

The audital bullæ, the external auditory meatus and the fenestration of the maxillæ in *Sylvilagus* show nothing distinctive and may be said to represent normal degrees of development.

The angular process of the mandible is rather larger and more rounded, as compared with *Lepus*. The ascending ramus is of moderate development, resembling that of *Lepus*.

*Teeth* (pl. xci, 9; figure 44, 2 and 3).—The following are the characters of the teeth of the genus *Sylvilagus*, which, with the exception of the front upper incisors and first lower premolar, and smaller size throughout, are not different from those of the teeth of *Lepus*: First upper incisors with longitudinal groove in anterior face always simple, usually shallow and filled with cement only in a few specimens from Mexico. The first upper maxillary tooth has typical folding of enamel on the anterior surface, a deep median reentrant angle on either side of which is a smaller reentrant angle. The first lower molariform tooth has a small reentrant angle on its anterior surface and a shallow, broader reentrant angle on the external surface of the anterior half of the tooth. In some of the specimens of *Sylvilagus*, from Mexico, the anterior face of this tooth is marked by two reentrant angles, instead of the usual one, the tooth in this case resembling the first lower premolar of *Limnolagus*. The second, third, fourth, and fifth upper molariform teeth show each a deep reentrant angle extending from the internal face about three-quarters the distance across the tooth; the adjacent edges of this angle are almost in contact with one another throughout their whole extent. The enamel of the reentrant angle is crenated. In the second, third, and fourth lower molariform teeth the lateral diameter of the posterior half of each tooth is about four-fifths of the lateral diameter



of the anterior half of the tooth. The last upper molar is small with an elliptic cross section. The last lower molar is a small double cylinder in form, the anterior half of which is larger and elliptic in section, the posterior half terete.

*Vertebral Column.*—The cervical vertebræ (pl. XCII, 5) of *Sylvilagus* have nothing to distinguish them from the same vertebræ of many other genera, being noticeably different from those of *Lepus* and *Pronolagus* only. The cervicals are uniformly shortened, the costal processes project laterally farther from the sides of the centrum, the anterior and the posterior spines of these processes are less prominent, than in *Lepus*. The true transverse process is more conspicuous and is often found to project laterally from the side of the fifth vertebra.

The length of a neural spine in the anterior thoracic region is about twice the length of the centrum, to which it is attached. The anticalinal vertebra is usually the eleventh, but often the tenth. Metapophyses are usually seen only on the tenth, eleventh, and twelfth thoracic vertebræ, sometimes on the ninth.

The lumbar vertebræ (pl. XCIV, 14) are scarcely distinguishable from the same in *Oryctolagus*. The transverse processes instead of arising abruptly from the anterior half of the lateral aspect of the centra as they do in *Lepus*, arise from the whole side, so that the angle between the process and the centrum is partly filled in with bone, but this is not comparable to the filling in that takes place in *Limnolagus* and in *Romerolagus*. True anapophyses are lacking, the neural spines and metapophyses show nothing of interest. The hypophysis on the second lumbar is the longest, that on the first is next in length, and the shortest is found on the third. Sometimes the first hypophysis is reduced to a ridge and the third is lacking.

The sacrum differs in no way from the description given in the general account.

The caudal vertebræ vary from eleven to fifteen in number. The larger number is the more usual. Of the different forms (see p. 363) of vertebræ in this region, one, or often two, is of the first form; five to seven of the second, usually six; four to seven of the last form, usually six or seven. The skeleton with the lowest number of caudals, eleven, is *Sylvilagus minensis* THOMAS. The decrease takes place in the last form, which is here reduced to four in number.

*Sternum and Ribs.*—The sternum (pl. XCV, 2) of *Sylvilagus* is not very characteristic. In general it resembles the sternum of *Lepus*. The presternum is relatively larger, the keel less prominent anteriorly. The first pair of ribs is attached just in front of its

middle. The mesosternal segments have a tendency to be less flattened than they are in *Lepus*. The xiphisternum is shorter than the presternum, its ends moderately enlarged, the posterior end being more enlarged, relatively, than in *Lepus*.

The ribs (pl. xciv, 5) are somewhat peculiar, but there is nothing to distinguish them from the ribs of *Oryctolagus*. The shafts of the anterior ribs are only moderately enlarged in their ventral portions. The spine-like portion of tubercles is well developed on all the skeletons except that of *Sylvilagus minensis* where the spines are poorly developed and are last seen on the seventh pair of ribs instead of on the eighth as in the others.

*Shoulder Girdle and Upper Extremity.*—The scapula (pl. xcvi, 7) of *Sylvilagus* is different in form from the same bone of *Lepus*, *Romerolagus*, and *Pronolagus*, but shows nothing tangible by which it can be distinguished from the scapulæ of the other genera. It is relatively narrow, the superior border relatively less convex, the antero-superior angle moderately pronounced, and the suprascapular fossa relatively narrow, when compared with the scapula of *Lepus*.

Regarding the humerus of *Sylvilagus* there is nothing peculiar by which it can be distinguished from the humeri of many of the other genera.

The forms, relations, sizes, and positions of the radius and ulna (pl. xcvi, 4) are alike in *Sylvilagus* and in *Limnolagus*. These bones are subequal in size; the ulna is not reduced in the middle of its shaft, and is situated external to radius rather than behind it. Both bones are moderately slender. The radius is equal to the humerus in length.

The carpus, the metacarpus, and the phalanges of *Sylvilagus* are entirely similar in form and position to these bones in any of the Leporidæ, as detailed in the general account of the wrist and hand (p. 378).

*Pelvis and Lower Extremity.*—The os innominatum has about the same general form in *Sylvilagus* and in *Oryctolagus*. The ilium is not wide and shovel-like. The anterior edge of the acetabulum is about midway between the extreme anterior and posterior points of the os innominatum or just a little posterior to the middle point. The antero-superior angle of the ilium is rather obliquely rounded off. The obturator foramen is apparently less rotund than is the case with *Lepus*.

The femur, the tibia, and the fibula of *Sylvilagus* are typical for the family, as detailed in the general account (p. 382), and show nothing that is peculiar to the genus.

The greatest length of the foot about equals the length of the tibia, but in one skeleton, No. 94,197, from Nevada, the foot is longer than the tibia, in this respect resembling the foot and tibia of *Brachylagus*.

The basal width of the metatarsus is contained two and a half times into the length of the third metatarsal, as is commonly the case among other Leporidae.

The combined length of the phalanges of the two lateral digits, as well as of the two middle ones, is usually approximately equal to the length of the metatarsals to which they belong.

The genus *Sylvilagus* stands second to *Lepus* in point of number of species and extent of geographic distribution. It is a fairly homogeneous group. A few forms have been classed as a separate subgenus, an arrangement which is here retained. The teeth on the whole are formed as they are in typical *Lepus*. Certain of the Mexican species, however, have the first lower premolar as it is in *Limnolagus*.

In the form of the cervical vertebrae and the shape of the transverse processes of the lumbar vertebrae, the relative size of the radius and ulna, and in the shape of the pelvis and the ribs, sternum, and scapula, *Sylvilagus* seems to be generally similar to *Oryctolagus*. The teeth in these two genera are essentially alike.

There are two subgenera of *Sylvilagus*—*Sylvilagus* proper and *Microlagus*. No skeletons of the latter are available for examination.

#### Subgenus SYLVILAGUS Gray

1867. *Sylvilagus* GRAY, Ann. Mag. Nat. Hist., XX, 3d ser., p. 221.

1896. *Sylvilagus* MEARNS, Proc. U. S. Nat. Mus., XVIII, p. 551. June 24, 1896.

1899. *Sylvilagus* MAJOR, Trans. Linn. Soc. London, 2d ser., VII, p. 514, November, 1899.

*Type*.—*Sylvilagus floridanus mallurus* (THOMAS).

*Geographical Distribution*.—Same as for the genus.

*Diagnosis and Description*.—Size larger, skull (pls. LXXVI, 7, 8; LXXVII, 2; LXXXVI; LXXXVII, 1-10) heavier, rostrum often heavier and not so pointed. Postorbital processes long and narrow, attached to skull by a very broad pedicle. The anterior part of the process short, attached to the side of the skull for nearly its whole length. Posterior part of the process long and narrow, the posterior edge touching the cranium, the process thus enclosing a very narrow clavate slit, much narrower than the width of the postorbital, which helps to form it.

Species in this subgenus, see p. 336.

**Subgenus MICROLAGUS Trouessart**

1867. *Microlagus* TROUSSERT, *Catalogus Mammalium*, I, fasc. iii, p. 660.

*Type*.—*Sylvilagus* (*Microlagus*) *cincrasceus* (ALLEN).

*Geographical Distribution*.—Western and southwestern United States and northern Mexico.

*Diagnosis and Description*.—Externally like *Sylvilagus*, size small, skull (pls. LXXVI, 9, 10; LXXVII, 1; LXXXVI; LXXXVII, 11-13) light, rostrum rather straight, narrow, pointed; postorbital process attached to skull by a narrow pedicle, the anterior portion of the postorbital more or less free from the skull, and helping to form a well-marked notch. Posterior portion of postorbital rather slender. It may or may not touch the side of the cranium; when it does, it incloses a clavate foramen, fully as wide as the posterior limb of the process.

For the species belonging to this subgenus, see pp. 336, 337.

**Genus ORYCTOLAGUS Lilljeborg**

1867. *Cuniculus* GRAY, *Ann. Mag. Nat. Hist.*, 3d ser., XX, p. 225.

1874. *Oryctolagus* LILLJEBORG, *Sveriges och Norges Rygggradsdjur*, I, p. 417.

1899. *Oryctolagus* MAJOR, *Trans. Linn. Soc. London*, 2d ser., VII, Zool., November, 1899, p. 514.

*Type*.—*Lepus cuniculus* LINNÆUS.

*Geographical Distribution*.—Southern and western Europe and northern Africa.

*Diagnosis*.—Externally similar to *Lepus*, but ears and hind feet relatively shorter. Postorbital process large but not wide and triangular; its posterior limb does not touch side of cranium. Sutures of the interparietal distinct. Choanæ very narrow, incisive foramina and least length of palate subequal, width of choanæ much less than either. Teeth essentially as in *Lepus*.

*Skull* (pls. LXXVI, 2, 5; LXXVII, 5; LXXXVIII; LXXXIX, 1-5).—The postorbital processes are large, but not wide and triangular; they do not stand out from the side of the skull to a marked extent. The process is arched. Neither the anterior nor the long and rather pointed posterior portions meet the side of the cranium in the wild rabbits. Anterior and posterior notches are thus formed. In two of the skulls of domestic rabbits at hand, a lop-eared and a Belgian hare, the anterior angle of the postorbital meets the frontal bone, and in the lop-ear forms the outer boundary of an irregular foramen, while in the Belgian hare the whole anterior angle is fused to the cranium so that even the foramen is obliterated. In both these specimens posterior notches are present.

The interparietal is present as a distinct bone in *Oryctolagus*.

The bony palate is relatively long. The horizontal plate of the palate bone well developed. It enters into the formation of the bony palate to a greater extent than it does in *Lepus*, where it forms a fourth to a third of the bony palate, and to a less extent than it does in *Romerolagus* where it is about half of the bony palate. The portion of the palate bone that borders the maxilla caudad of the posterior edge of the bony palate is moderately developed and thus helps to form part of the roof of the mouth along the posterior dental alveoli. The distance between the vertical plates of the palate bones, that is the width of the choanæ, is very slight, less than it is in any other genus. The pharyngeal vault is high. The length of the bony palate, measured midway between the median line and the inner edge of the dental alveoli, is about equal to the greatest width of the incisive foramina, which are narrow in this genus, and it is much greater than the least distance between the two vertical plates of the palate bones.

The posterior palatine foramina are of moderate size and situated in the usual position at the anterior outer angles of the horizontal plates of the palate bones.

The anterior portion of the zygoma is deep, as it is in *Lepus*, but the under edge of the posterior portion is cut away, rendering it shallower. The antero-inferior angle of the zygoma is enlarged and flares outward to a rather marked extent. The foot-like extremity of the zygomatic process of the squamosal is enlarged. The lateral length of the squamoso-malar suture is contained between one and one and a half times in the superior border of the malar, measured from the anterior edge of that suture to the antero-inferior angle of the orbit. The posterior free extremity of the malar is long.

The audital bullæ, the fenestration of the maxillæ, and the shape of the mandible in *Oryctolagus* show nothing distinctive of the genus, and may be said to represent normal degrees of development.

*Teeth* (pl. XCI, 5; figure 44, 22).—First upper incisors, with longitudinal groove on anterior face, always simple, moderately shallow and unfilled with cement. First upper maxillary tooth has typical folding of enamel on the anterior surface, a deep median reentrant angle, on either side of which is a smaller reentrant angle. The first lower molariform tooth has a small reentrant angle on its anterior face, and a shallow broader reentrant angle on the external surface of the anterior half of the tooth which is separated from the posterior half by a single reentrant angle. The second, third, fourth, and fifth upper molariform teeth show each a deep reentrant angle

extending from the internal face about three-quarters the distance across the tooth. The adjacent edges of this angle are almost in contact with one another throughout their whole extent and crenated. In the second, third, and fourth lower molariform teeth the lateral diameter of the posterior half of each tooth is about four-fifths the lateral diameter of the anterior half of the tooth. The last upper molar is very small, with an elliptical outline. The last lower molar is also small, consisting of a larger anterior elliptic portion and a smaller posterior portion, circular in outline.

*Vertebral Column.*—The cervical vertebræ (pl. XCII, 6) of *Oryctolagus* have nothing to distinguish them from the same series of vertebræ of several other genera, being noticeably different only from the two extremes, *Lepus*, with elongated cervicals on the one hand, and *Pronolagus*, with more shortened ones, on the other. The cervicals are uniformly shortened, the costal processes project relatively far from the sides of the centrum; the anterior and the posterior spines of these processes are less prominent than they are in *Lepus*. The true transverse process is more conspicuous and is often found to project laterally from the side of the fifth vertebra.

The length of the neural spines in the anterior thoracic region is about three times the length of a centrum. The anticlinal vertebra is the eleventh, on the lop-eared domestic it is the tenth, however. Metapophyses are well developed on the tenth, eleventh, and twelfth thoracic and are indicated on the ninth by small tubercles.

The lumbar vertebræ (pl. XCIII, 4, 5) are scarcely distinguishable from the same series of vertebræ in *Sylvilagus*. The transverse processes do not arise abruptly from the anterior half of the lateral aspect of the centra, but from the whole side, so that the angle between the process and the centrum is partly filled in with bone, but in no way comparable to the filling in that takes place in *Limnolagus* and in *Romerolagus*. Anapophyses are best developed in this genus of all the Leporidae. In the skeleton of the lop-eared domestic, these processes are very large; in the three middle vertebræ of the lumbar series, the third, fourth, and fifth, the anapophyses extend as far caudad as the posterior border of the metapophyses of the next succeeding vertebra. In the two skeletons of wild *Oryctolagus*, however, this great development of the anapophyses is not so pronounced, but they are much larger than they are on the lumbar vertebræ of any of the other skeletons.

The hypophyses are injured in the skeletons of the wild animals, but from what remains of them it would appear that the second hypophysis is the longest, as it is in the lop-eared domestic.

The sacrum of *Oryctolagus* differs in no way from the description given in the general account, p. 362.

The caudal vertebræ are about seventeen in number, one being of the first form (see p. 363), six to eight of the second, and the last eight or nine are the rudimentary elongated centra, without neural canal or processes.

*Sternum and Ribs.*—The sternum (pl. xcv, 5) in *Oryctolagus* is in general as in *Lepus*. The presternum is more conspicuously keeled; the first pair of ribs attached just anterior to its middle. The mesosternal segments are more compressed from side to side than they are in *Lepus*. The last is much shorter than any of the other mesosternal segments. The xiphisternum is large and stout, longer than the presternum, its posterior end about as much enlarged as its anterior.

There is nothing by which the ribs of *Oryctolagus* can be distinguished from the ribs of *Sylvilagus*. The shafts of the anterior ribs are scarcely enlarged in their ventral portion. Spine-like portions of the tubercles of the ribs are well developed, and are last seen in the eighth pair.

*Shoulder Girdle and Upper Extremity.*—The scapula (pl. xcvi, 3) of *Oryctolagus* is different in form from the same bone in *Lepus*, *Romerolagus*, and *Pronolagus*, but shows nothing tangible by which it can be distinguished from the scapulæ of the other genera. It is relatively narrow, the superior border relatively convex, the antero-superior angle moderately prominent, and the supraspinous fossa relatively narrow, as compared with the scapula of *Lepus*.

Regarding the humerus of *Oryctolagus* there is nothing by which it can be distinguished from the humeri of many of the other genera.

The form, relative sizes, and positions of the radius and ulna are nearly alike in *Oryctolagus*, *Sylvilagus*, *Pronolagus*, and *Limnolagus*; that is, the ulna is not reduced in the middle of its shaft and is situated external to the radius rather than behind it. In *Oryctolagus* the ulna is somewhat heavier than the radius and both bones are rather heavier than they are in the other genera mentioned above. The radius is equal to the humerus in length.

The carpus, the metacarpus, and the phalanges of *Oryctolagus* are entirely similar in form and position to these same bones in any of the Leporidae, as detailed in the general account of the wrist and hand (p. 378).

*Pelvis and Lower Extremity.*—The os innominatum has about the same general form in *Oryctolagus* and in *Sylvilagus*. The ilium is not wide and shovel-like except in the lop-eared domestic. The

antero-superior angle is rather obliquely rounded off. The anterior edge of the acetabulum is about midway between the extreme anterior and the extreme posterior points of the bone. The obturator foramen is less rotund than it is in *Lepus*.

The femur, the tibia, and the fibula of *Oryctolagus* are typical for the family Leporidae, as detailed in the general account (p. 382), and show nothing that is peculiar to the genus.

The greatest length of the foot about equals the length of the tibia.

The basal width of the metatarsus is contained two and a half times in the length of the third metatarsal, as is commonly the case among the Leporidae.

The combined length of the phalanges of the two lateral digits, as well as of the two middle ones, is approximately equal to the length of the metatarsals to which they belong.

Species in the genus. One, *O. cuniculus* (LINNÆUS).

*Oryctolagus* is a well-marked genus. In spite of a rather extensive geographic distribution, only one species has been recognized. It seems to have few relationships with the other Old World genera. With *Sylvilagus* in America, it has certain points of resemblance, in the shape of the transverse processes of the lumbar vertebræ, of the scapula, in the relative size of the radius and ulna, in the shape of the pelvis and of the ribs and sterna. The skulls of the two genera taken as a whole are not markedly different, and the teeth are essentially alike.

*Oryctolagus* has been extensively domesticated, and many stable varieties produced, among them the Belgian hare, but the true generic characters are never lost, and some of them, as the keeled presternum and the large anapophyses of the lumbar vertebræ are even better marked in the domestic rabbits than they are in the wild ones.

#### Genus LIMNOLAGUS Mearns

1867. *Hydrolagus* GRAY, Ann. Mag. Nat. Hist., xx, 3d ser., 1867, p. 221.

1897. *Limnolagus* MEARN'S, Science, n. s., v, March 5, 1897, p. 393.

1899. *Limnolagus* MAJOR, Trans. Linn. Soc. London, 2d ser., vii, Zool., November, 1899, p. 514.

*Type*.—*Limnolagus aquaticus* (BACHMAN).

*Geographical Distribution*.—Austro-riparian faunal area of North America, in general the South Atlantic and Gulf states.

*Diagnosis*.—Externally similar to *Sylvilagus*, but pelage harsher; ear, tail, and hind foot relatively shorter, the latter scantily haired. Skull much as in *Sylvilagus*, but postorbital process fused to side of cranium for its whole length, forming neither notch nor foramen.



Teeth essentially as in *Lepus*, except first lower premolar which has two or more reentrant angles on anterior face.

*Skull* (pls. LXXVI, 3, 6; LXXXVII, 4; LXXXVIII; LXXXIX, 6-10).—The genus *Limnolagus* possesses postorbitals quite different in form and attachment from the postorbitals of any of the other genera of the Leporidae. The whole process is fused to the side of the frontal bone, so that only a very minute notch is found anteriorly, and no notch, foramen, or slit is found posteriorly, except in rare and anomalous cases, in which a small foramen may be formed by incomplete fusion of the postorbital with the side of the skull. The fused postorbital process has about the same general shape as has the unfused process in the genus *Sylvilagus*. An atypical specimen (No. 64,029, Kissimmee, Florida) shows the manner in which the process is attached. The hind-end of the process, instead of meeting the skull directly as it does in those genera where the posterior end of the process is in contact with the side of the skull, is met by an outgrowing process from the cranium. In this specimen a small foramen is enclosed between the posterior part of the postorbital process and the above outgrowing process from the cranium. A more or less prominent blunt projection, not seen in the other genera, is formed by the union of the postorbital process with the outgrowing process from the cranium. The blunt projection above, together with the root of the zygomatic process just below, forms a rather conspicuous notch.

The interparietal is present as a distinct and separate bone.

The bony palate is relatively long, about as it is in *Oryctolagus*, longer than in *Lepus* or *Sylvilagus*, shorter than in *Pronolagus* or *Romerolagus*. The horizontal plate of the palate bone is relatively well developed, to about the same extent as in *Oryctolagus*, forming between a third and a half of the bony palate. The portion of the palate bone bordering the maxilla caudad of the posterior edge of the bony palate is moderately well developed, much better than it is in *Lepus*, much less than it is in *Romerolagus*. The posterior palatine foramina, of moderate size, are located at the anterior outer angles of the horizontal plates of the palate bones. The choanae are moderately wide, narrower than in *Lepus*, but not approaching the extreme narrowness seen in *Oryctolagus*. The length of the bony palate taken midway between the median line and the dental alveoli is about equal to the width of the choanae and to the greatest width of the incisive foramina taken together.

The zygoma is heavy, thick, and deep, its antero-inferior angle is much expanded and flares outward, more so than it does in any

other genus except *Romerolagus*. The foot-like extremity of the zygomatic process of the squamosal is short, about as it is in *Lepus*, but the posterior free extremity of the malar is long.

The audital bullæ and the external auditory meatus are typical for the family as detailed in the general account (page 346).

The fenestration of the maxillæ is reduced to a small degree, being about as it is in the genera *Pronolagus* and *Romerolagus*.

The mandible of *Limnolagus* has a very large, rounded, angular process, similar to the form in *Sylvilagus*, but the ascending ramus is relatively wider.

*Teeth* (pl. XCI, 4; figure 44, 4).—The first upper incisor in *Limnolagus* has a shallow, simple groove in front, filled with cement. The first upper molariform tooth has the three usual reentrant angles, a deeper median one and two lateral shallower ones. The first lower molariform tooth, divided into an anterior and a posterior portion by a single deep reentrant angle from the external face, presents on its anterior face two deep crenated reentrant angles and one or two smaller ones, and a broad crenated reentrant angle on the anterior half of the external surface. The whole anterior half of the tooth is rather solid looking, and more quadrilateral in outline than is usually the case with this tooth in other genera. The second, third, fourth, and fifth upper molariform teeth have each a deep, internal reentrant angle, extending about three-quarters the distance across the tooth as in *Lepus*, *Oryctolagus*, and *Sylvilagus*, but unlike them the internal fourth of the reentrant angle is rather wide, that is, its adjacent edges are not in contact for that fourth. The second, third, and fourth lower molariform teeth have each the lateral diameter of the posterior half of the tooth equal to about four-fifths the lateral diameter of the anterior portion. The last upper molar is small, elliptical in section. The last lower molar is also small, consisting of anterior and posterior portions which are more nearly subequal in size than they are in most of the genera. The anterior part is the larger and more elliptical, the posterior smaller and more rotund in outline.

*Vertebral Column*.—The cervical vertebræ (pl. XCII, 4) of *Limnolagus* have nothing to distinguish them from the same vertebræ of several other genera, being noticeably different only from the two extremes, *Lepus* with elongated cervicals, and *Pronolagus* with more shortened ones. The individual vertebræ are uniformly shortened, the costal processes project relatively far from the sides of the centrum, the anterior and posterior spines of these processes are less prominent than they are in *Lepus*. The true transverse process is

more conspicuous and is found to project laterally from the side of the fifth vertebra.

The length of a neural spine in the anterior thoracic region is about equal to twice the length of a centrum. The tenth thoracic is the anticlinal vertebra. Well developed metapophyses are found on the last four thoracic vertebræ.

The lumbar vertebræ (pl. XCIV, 13) of *Limnolagus* are quite peculiar. The transverse processes are shorter and much broader than they usually are in the Leporidæ, the longest being equal to the length of the centrum to which it is attached and a fourth of the centrum in front. Their breadth makes them appear shorter than they really are. The free extremity of the transverse process is more expanded than it is in any other genus except *Romerolagus*. The attached base is very wide, coming from the whole side of the centrum, so that the angle between the main axis of the transverse process and the side of the centrum is filled in with thin bone, approaching the condition found in *Romerolagus*. This character of the transverse process is especially marked in the anterior part of the lumbar series. The spinous processes of the lumbar vertebræ are low, triangular in outline, and directed forward. True anapophyses are lacking. The hypophyses are injured in the single available skeleton, but it is probable that the second was the longest.

The sacrum differs in no way from the description given in the general account (page 362).

The total number of caudal vertebræ in *Limnolagus* is eleven, of which the first is long with a complete neural arch, the next five are shorter, wider, with more or less evident transverse processes, and the terminal five consist of small rudimentary centra without neural arches or processes.

*Sternum and Ribs* (pls. XCVI, 5; XCIV, 6).—The anterior portion of the presternum of *Limnolagus* is considerably enlarged laterally, having a tendency to be intermediate in form between the presternum of *Lepus* and that of *Romerolagus* and *Ochotona*. The mid-ventral line of this expanded part bears a low keel which is not extended backward on the posterior portion of the presternum. The first pair of ribs is attached to the middle of the sides of the presternum. The mesosternum of *Limnolagus* as a whole is wider than it is in most of the other genera. It is also shorter, so that its length is but little greater than that of the presternum or of the xiphisternum, both of which are subequal. The first, second, and third mesosternal segments are about equal in length, the fourth is shorter. Each successive segment is wider than the one immediately in front. The third

and fourth segments are completely ankylosed so that the whole mesosternum is composed of but three separate pieces instead of the usual four. The xiphisternum is long and slender and about equally expanded at each end.

In all the other genera except *Romerolagus*, the sixth and seventh pairs of ribs are attached to the last piece of the mesosternum. In these two genera the last rib attached directly to the sternum is the sixth, the seventh rib being attached to the cartilage of the sixth near the point where the latter joins the mesosternum.

The spine-like portions of the tubercles of the ribs in *Limnolagus* are well developed, but are not conspicuous, owing to the fact that the angle between the tubercle and the posterior edge of the rib is filled in with bone, making that part of the rib very wide, so that it is distinctly the widest portion of the rib. In the single skeleton at hand the last rib to bear a spine-like tubercle on the right side is the seventh, while on the left side it is the sixth. The shafts of the anterior ribs are not widened ventrally.

*Shoulder Girdle and Upper Extremity.*—The scapula (pl. xcvii, 6) of *Limnolagus* is different in form from the same bone in *Lepus* and in *Romerolagus* but shows nothing tangible by which it can be distinguished from the scapulæ of the other genera. It is relatively narrow, the superior border relatively convex, the antero-superior angle moderately pronounced, and the supraspinous fossa relatively narrow.

There is little about the humerus of *Limnolagus* by which it can be distinguished from the humeri of many of the other genera, but the groove subtending the internal condyle is rather less marked than in any of the Leporidae except *Romerolagus*. The external condyloid ridge is short but comparatively wide, a trifle more conspicuous than it is in the other genera except *Romerolagus*.

The form, relative sizes, and positions of the radius and ulna (pl. xcvi, 5) are quite alike in *Limnolagus* and in *Sylvilagus*. These bones are subequal in size; the ulna is not reduced in the middle of its shaft; it is situated external to the radius, rather than behind it. Both bones are moderately slender. The radius is equal to the humerus in length.

The carpus, the metacarpus, and the phalanges of *Limnolagus* are entirely similar in form and position to these same bones in any of the Leporidae, as mentioned in the general account of the wrist and hand (page 378).

*Pelvis and Lower Extremity.*—*Limnolagus* has wide ilia, much like those of *Lepus*, but the antero-superior angle is not obliquely

rounded off. The antero-ventral angle is produced into a blunt, very short spine. The horizontal rami of the pubic bones slope backward more than in the other genera with the exception of *Romerolagus*.

The femur and the fibula of *Linnolagus* are typical for the family Leporidae, as detailed in the general account (page 382). The tibia (pl. xcix, 10) of *Linnolagus* however is relatively heavier than in the other genera excepting *Romerolagus*. It resembles that of the latter genus in the fact that it is rather curved, the inner surface of the lower part of the shaft being concave.

The foot (pl. c, 5) is about equal in length to the tibia. As in the other genera, the basal width of the metatarsals is contained about two and a half times in the length of the third metatarsal. The combined lengths of the phalanges of each toe is about equal to the length of the metatarsal of that toe.

Species in the genus *Linnolagus*, see page 337.

*Linnolagus* is a well-marked genus. It has a number of characters associating it with *Sylvilagus* on the one hand and with *Romerolagus* on the other. The radius, the ulna, the hind foot, the pelvis, and the scapula are much alike in *Linnolagus* and *Sylvilagus*. Occasionally abnormal individuals show postorbital processes somewhat alike in the two genera.

The palatal region of *Linnolagus* shows some resemblance to the same region in *Romerolagus*, while the whole sternum and the shape of the transverse processes on the lumbar vertebrae and the degree of development of the tail are intermediate in character between these structures in *Romerolagus* and *Sylvilagus*.

#### Genus BRACHYLAGUS Miller

1900. *Brachylagus* MILLER, Proc. Biol. Soc. Washington, XIII, p. 157, June 13, 1900.

*Type*.—*Brachylagus idahocensis* (MERRIAM).

*Geographical Distribution*.—Upper Sonoran faunal area, in southern Idaho, in northern Nevada and California, and in eastern Oregon and Washington.

*Diagnosis*.—Externally similar to *Lepus*, except that the tail is unusually short. Skull essentially like that of *Lepus* but with interparietal distinct; auditory bullae relatively larger than in any of the related genera. First upper premolar with only one reentrant angle on anterior face. Reentrant angles of upper molariform teeth extending only half-way across the tooth and not crenate.

*Skull* (pl. LXXVIII, 3; LXXIX, 1).—*Brachylagus* is the smallest of

all the rabbits examined and consequently has the smallest skull. As a whole the skull is short and wide, arched antero-posteriorly. The brain-case is inflated.

The postorbital processes are small and slender, free both in front and behind, forming anterior and posterior notches with the cranium proper.

The interparietal bone is distinct.

The bony palate is shorter than in any other genus, its least length being equal to twice the length of  $M^1$ . Its extreme posterior edge only is formed by the horizontal plates of the palate bones. The incisive foramina are wide, the widest part of each one nearly equaling the length of the bony palate. The distance between the vertical plates of the palate bones is relatively as great as it is in *Lepus*, and much exceeds the length of the bony palate.

The zygoma is deep and thin, only slightly expanded at the antero-inferior angle. The posterior free extremity of the malar is moderately enlarged. The foot-like extremity of the zygomatic process of the squamosal is rather short, but not relatively so short as it is in *Lepus*.

The audital bullæ are much inflated and the external auditory meatus is very large and rounded.

The mandible has the general form of the mandible of *Lepus*, but the angular process is relatively smaller and its edge is nearly straight.

*Teeth* (pls. XCI, 1; fig. 44, 1).—*Brachylagus* has the simplest teeth of any of the Leporidae available for examination. The enamel lacks much of the folding and the crenation found in the other genera. The first upper incisor has a simple groove, not filled with cement. The first upper premolar is very simple, presenting a single reentrant angle instead of the usual three on the anterior face. The infolding of the enamel on the inner sides of the four upper molariform teeth extends as far as the middle of each tooth only and lacks the crenation so distinctly seen in the case of the other genera. The anterior lower premolar is also simple. It is divided into an anterior and a posterior portion by a single deep reentrant angle extending in from the external face. It has no infolding of the enamel in front, none on the inner side of the anterior half of the tooth, and a single wide, shallow infolding on the outer side of the anterior portion of the tooth. The posterior transverse portions of the three lower molariform teeth are relatively much shorter than they are in any of the other Leporidae. The lateral length of each posterior portion is equal to about half the lateral length of the anterior

portion to which it belongs. In all the other genera the anterior and posterior portions of the three lower molariform teeth are subequal or nearly so. The enamel between the two portions of these teeth is not crenated as in the other groups.

*Vertebral Column.*—The cervical vertebræ (pl. XCII, 3) of *Brachylagus* have practically the same form that they have in the large genus *Sylvilagus*, that is, they belong to the shorter type.

In the anterior part of the thoracic series of vertebræ, the length of the neural spine is about equal to three times the length of the centrum to which it is attached. The tenth thoracic is the anticlinal vertebra; its spine is abruptly broader than any of the spines in front and is concave on its anterior and also on the posterior edge. The anterior edge of the eleventh is slightly concave and is perpendicular in its general direction; the posterior edge is concave and slopes backward and downward from above. The spine of the last thoracic is smaller than that on the eleventh and resembles in form the spines of the lumbar series. Well developed metapophyses are found on the last three thoracic vertebræ, and on the ninth this process is distinctly indicated by a small spine. The last two vertebræ of this series have rather well marked ventral ridges.

The lumbar series of vertebræ (pl. XCIV, 12) in *Brachylagus* is quite different in some respects from the same series in the other genera. The best distinguishing character is a prominent longitudinal rounded ridge extending the length of the long axis of the transverse processes. The process itself is rather long and slender, is rather more curved and concave anteriorly than the lumbar transverse process in the other genera. The longest process has a length of one and a half times that of the centrum to which it is attached. The process does not rise abruptly from the side of the centrum, but slopes gently into it at the posterior angle of its attachment, as in *Sylvilagus* and in *Oryctolagus*. The neural spines are low, especially anteriorly. Anapophyses are slightly more developed on the anterior three or four vertebræ of this series than they are in other genera, except *Oryctolagus*.

The sacral vertebræ are four in number and differ in no essential respects from the same vertebræ in other genera.

The caudal series of vertebræ is very short in *Brachylagus*, the total number being nine, the smallest that occurs in any genus except *Romerolagus*, which has the same number, and *Nesolagus* which has eight. The first two caudal vertebræ are long, with complete neural arches, and resemble the last sacral vertebræ, the next three are shorter, with rather wide transverse processes, the last four are

small, rudimentary centra, longer than wide and without processes of any kind.

*Sternum and Ribs* (pls. xcv, 1; xciv, 7).—The structure of the sternum of *Brachylagus* is fairly characteristic of the genus. The presternum is compressed, bearing a low keel along the whole ventral border. The dorsal portion of the presternum is somewhat enlarged laterally just anterior to the attachment of the first pair of ribs, which takes place at the junction of the anterior and middle thirds. The mesosternum consists of four distinct segments, of which the first is compressed laterally, with a low keel continuing that of the presternum. The succeeding mesosternal segments become successively wider, and more flattened dorso-ventrally. The last segment is much wider than any of the others, with well marked postero-lateral angles, for the attachment of the sixth and seventh pairs of ribs. The xiphisternum is decidedly longer than the presternum, is slender in the middle but considerably expanded at the ends, especially the posterior one.

The ribs are not very characteristic in *Brachylagus*. In general they resemble those of *Sylvilagus*. The spine-like portion of the tubercles are but moderately developed and are last seen on the seventh pair of ribs. The lower part of the shafts of the anterior ribs is but slightly broadened.

*Shoulder Girdle and Upper Extremity*.—There is apparently nothing about the shoulder blade (pl. xcvi, 8) of *Brachylagus* except the smaller size by which to distinguish it from the scapulæ of several other genera. It belongs to the moderately narrow type with a relatively straighter and less convex vertebral border, with the antero-superior angle of the more pronounced type, and the supraspinous fossa relatively narrower.

There is little in the humerus of *Brachylagus* that is peculiar. It is small and relatively more slender than in other genera except *Romerolagus*. The groove subtending the internal condyle is moderately developed. The external condyloid ridge is rather wide for one of the Leporidae, like that of *Romerolagus*, but not quite so long.

In *Brachylagus* the radius and ulna (pl. xcvi, 6) are subequal in size, and in general resemble those bones in *Sylvilagus*, *Oryctolagus*, *Pronolagus*, and *Limnolagus*. Unlike any of those skeletons, however, with bones of the foramen equally developed, the radius is distinctly shorter than the humerus, in the other cases the humerus and radius are subequal in length.

The carpal bones, the metacarpals, and the phalanges of *Brachy-*



*lagus* are entirely similar in form and position to these bones in any of the Leporidae, as detailed in the general account of the wrist and the hand (page 378).

*Pelvis and Lower Extremity.*—The innominate bone in *Brachylagus* is smaller than it is in other genera. The anterior part of the ilium is of the narrow type with the antero-superior angle obliquely rounded off, in these respects resembling *Sylvilagus* and *Oryctolagus*. A tubercle in front of the acetabulum is more prominent in *Brachylagus* than in the other genera. The descending ramus of the pubis is slenderer, and the distance from the tuberosity of the ischium to the nearest edge of the obturator foramen is relatively shorter than it is in other Leporidae. The anterior edge of the acetabulum is about equidistant between the extreme anterior and posterior points of the os innominatum.

The femur, tibia, and fibula (pl. xcix, 8) of *Brachylagus* are typical for the family as detailed in the general account (page 382) and show nothing that is peculiar for the genus, but the fibula fuses with the tibia at a point relatively nearer the middle than it does in most of the genera. The femur is apparently relatively more slender than in the other genera.

The greatest length of the foot (pl. c, 3) in *Brachylagus*, unlike that of most of the skeletons except *Sylvilagus*, No. 94,197 from Nevada, is greater than the greatest length of the tibia. The basal width of the metatarsals is contained about two and one-half times in the length of the third metatarsal. The combined lengths of the three phalanges approximately equal the length of the metatarsal to which they are attached.

So far as known the genus *Brachylagus* contains but a single species, *B. idahoensis*, represented by two skeletons and several skulls.

*Brachylagus* is a very well marked genus. Its peculiar teeth and the ridge on the transverse process of the lumbar vertebræ are quite unlike anything else among the Leporidae, although it would appear from the published figures (Major, '99, pl. 37, fig. 17) of the teeth of *Nesolagus* from Sumatra that the latter has teeth resembling those of *Brachylagus*. Aside from that, however, the two genera have little in common. Apart from the structure of the teeth, *Brachylagus* appears somewhat related to *Microlagus*, judging from the skulls as a whole. The skeleton in general, aside from the reduced number of caudal vertebræ and the ridges on the transverse processes of the lumbar vertebræ, is much like the skeleton of *Sylvilagus*.

Genus **PRONOLAGUS** new

1867. *Lepus* GRAY, Ann. Mag. Nat. Hist., 3d ser., XX, p. 223.

1899. *Oryctolagus* MAJOR, Trans. Linn. Soc. London, 2d ser., VII, Zool., p. 514, November, 1899.

*Type*.—*Pronolagus crassicaudatus* (GEOFFROY).

*Geographical Distribution*.—South Africa.

*Diagnosis*.—Externally similar to *Lepus*. Skull and teeth essentially like those of *Romerolagus* except that audital bullæ are smaller than foramen magnum, and anterior face of first lower premolar has two reentrant angles.

*Skull* (pls. LXXVIII, 2a, 2b; LXXVII, 3).—The skull as a whole is long and narrow. The anterior angle of the postorbital process is entirely lacking or else is so intimately associated with the cranium that the process appears as a triangle, one whole side of which is attached to the cranium. Of the two other sides one is directed outward and somewhat forward and the other obliquely inward and backward, forming the outer boundary of a posterior notch. The posterior and only angle of the postorbital is pointed. The process, as a whole, closely resembles that of *Romerolagus*, but it is relatively as well as absolutely larger.

It cannot be definitely stated whether the interparietal of *Pronolagus* is obliterated in adult life or not. In the single available skeleton, which has evidence of being young, the sutures of this bone are partially obliterated.

The bony palate of *Pronolagus* is longer and narrower than in most of the Leporidae, its least length equaling four times the length of  $m^1$ , though the palate of *Romerolagus* approaches it closely. The incisive foramina are long and narrow, less triangular in outline than they are in most of the other genera. Their greatest width, taking both together, is much less than the length of the bony palate. The horizontal plates of the palate bones are large, and form a little less than half of the bony palate. The portion of the palate bone that borders the maxilla caudad of the posterior edge of the bony palate is developed to a greater degree than in any other genus except *Romerolagus*, and aids in forming to a considerable extent the lateral portion of the roof of the mouth just internal to the dental alveoli and posterior to the bony palate. The choanæ are considerably narrowed, almost approaching the narrowness seen in *Oryctolagus*, but the pharyngeal vault is only moderately high. The posterior palatine foramina are very small and would be scarcely noticeable were it not for the well-marked grooves leading from them. These foramina are located near the median line and not at the anterior external angles

of the horizontal plates of the palate bones, as in the case of the other genera of Leporidae.

The zygoma is rather thin and shallow; its antero-inferior angle is moderately enlarged. The foot-like extremity of the zygomatic process of the squamosal is rather short, about as it is in the genus *Lepus*. The posterior free extremity of the malar is short. The root of the zygomatic process takes its origin close to the squamoso-frontal suture, closer than in any other genus, although *Romerolagus* and *Linnolagus* show an approach to this condition.

The audital bullæ in *Pronolagus* are remarkably small.

The fenestration of the maxillæ is developed to a small extent only, about as in *Romerolagus* and *Linnolagus*.

The mandible in general is quite like that of *Lepus*, but the lower edge of the angular process is decidedly straight.

*Teeth* (pl. xci, 8; fig. 44, 23).—First upper incisor has the groove simple, very shallow, and unfilled with cement. The first upper molariform tooth has the three usual reentrant angles on the anterior surface very deep, deeper than they are in the other genera, except *Pentalagus*. The first lower molariform tooth, like the same tooth in *Romerolagus*, departs from the typical form. The tooth is divided into anterior and posterior portions not by a single reentrant angle extending inward from the external face, but by two reentrant angles, one from the internal, one from the external face, which meet near the center of the tooth. The external angle is the broader and shallower of the two. The internal is deeper and the adjacent sides of the angle are nearly in contact. The anterior limbs of both the reentrant angles are plain and heavy, the posterior limbs relatively narrower and decidedly convoluted. On the anterior face of the first lower molariform tooth are two deep, simple, reentrant angles. On the external face of the anterior portion of the tooth is a broad, shallow, reentrant angle. In the second, third, fourth, and fifth upper molariform teeth the reentrant angles extend nearly the whole distance across the teeth. The internal half of the angle is rather wide and open, differing in this respect from the other genera except *Romerolagus*. The enamel of the reentrant angles is crenated. The second, third, and fourth lower molariform teeth are divided by the usual deep reentrant angle, into anterior and posterior portions, the lateral diameters of which are equal to one another. The last upper molar is relatively larger in *Pronolagus* than in the other genera and its grinding surface is somewhat lozenge-shaped. The last lower molar has the reentrant angle which divides the tooth into a larger elliptical anterior portion and a smaller circular pos-

terior portion well marked. Owing to an extra fold of the reentrant angle the posterior face of the anterior portion of this tooth has a slight indentation not seen in the other genera.

*Vertebral Column.*—The greatest development of the shortened type of cervical vertebræ (pl. XCII, 10) is seen in *Pronolagus*. The costal process stands out very far from the body of the vertebræ; the process itself is narrow, that is, its antero-posterior dimensions are relatively much less than they are in the other genera. The cephalad and caudad projecting spines of the costal processes are apparently not well developed, but they have a somewhat worn or damaged look in the only skeleton. The general appearance of the cervical vertebræ in *Pronolagus*, seen from below, is much the same as in *Ochotona*.

The spines of the anterior thoracic vertebræ are equal to about two and a half times the length of their centra. The eleventh thoracic is the anticlinal vertebræ. Metapophyses are developed in the last four thoracic.

The transverse process of the lumbar vertebræ (pl. XCIII, 3) of *Pronolagus* is of medium length, the longest equaling the length of the centrum to which it is attached. It is not so much enlarged at the free extremity as it is in other genera. It is wide at the base where it comes from the whole side of the centrum, resembling *Limnolagus* in this respect, but the posterior border of the process is not so strongly concave as in that genus and the process itself is more slender. The spinous processes are low and triangular, like those of *Limnolagus*, *Romerolagus*, and *Pacilolagus*. The hypophyses are injured in the only available skeleton. Probably the second was the longest.

The sacrum differs in no way from the description given in the general account, page 362.

All but two of the caudal vertebræ are missing. These two resemble the sacral vertebræ in form.

*Sternum and Ribs* (pls. xcvi, 3; xciv, 3).—The posterior two-thirds of the presternum is much compressed, but not keeled; its anterior third is somewhat enlarged, resembling that portion of the presternum of *Limnolagus*. The first pair of ribs is attached at the junction of the first and second fourths. The mesosternal segments are more compressed laterally than they are in any of the other skeletons and each succeeding one is a trifle shorter than the one immediately in front. The xiphisternum is a little shorter than the presternum, is comparatively stout and about equally enlarged at each end.

The spine-like portions of the tubercles of the ribs are very small

and are last seen on the seventh pair of ribs. The shafts of the ribs are relatively narrow and there is no indication of the wide expansion found in *Lepus*. Decidedly the widest part of the rib is just behind the spine.

*Shoulder Girdle and Upper Extremity* (pl. xcviI, 4).—The scapula of *Pronolagus* is different in form from the same bone in *Lepus* and in *Sylvilagus*, and has relative proportions about the same as are found in *Romerolagus*. It is relatively long and narrow, the superior border relatively less convex, the antero-superior angle moderately pronounced, and the supra-spinous fossa relatively narrow.

Regarding the humerus of *Pronolagus* there is nothing peculiar by which it can be distinguished from the humeri of many of the other genera.

The form, relative sizes, and positions of the radius and ulna (pl. xcviII, 7) are much alike in *Pronolagus* and in *Oryctolagus*. The bones are about subequal in size; the ulna is not reduced in the middle of its shaft, and is situated external to the radius rather than behind it. Both bones are moderately slender. The radius is equal to the humerus in length.

The carpus, the metacarpus, and the phalanges of *Pronolagus* are entirely similar in form and position to these same bones in any of the Leporidae as detailed in the general account of the wrist and the hand (page 378).

*Pelvis and Lower Extremity*.—The os innominatum of *Pronolagus* resembles, in most respect, the same bone in the genera *Sylvilagus* and *Oryctolagus*, but the ilium is even narrower than it is in them, and its ventral edge is straight, in this respect resembling the ilium of *Romerolagus*.

The femur, the tibia, and the fibula (pl. xcix, 3) of *Pronolagus* are typical for the family as detailed in the general account (page 382) and show nothing that is peculiar for the genus.

The basal width of the metatarsus is contained about two and a half times in the length of the third metatarsal.

The combined lengths of the three phalanges of each of the hind toes approximately equal the length of the metatarsal to which they are attached.

The genus is represented by a single skeleton, *Pronolagus crassicaudatus* from South Africa.

*Pronolagus* is a peculiar genus, first classed as *Lepus* and later as *Oryctolagus*. It has not much to associate it with the former, and but little with the latter. In the structure of its teeth, postorbital processes, palate, and zygoma, it appears related to *Romerolagus*.

The sternum, however, is very similar to that of *Lepus*. The hind foot is nearly as short relatively as it is in *Romerolagus*. While I have seen no skins of *Pronolagus*, yet the fact that it has always been associated with *Lepus* or *Oryctolagus* makes it appear that its external features are not peculiar, which is all the more interesting, as the genus with which it has the most skeletal resemblances, *Romerolagus*, externally, bears certain resemblances to the pikas.

#### Genus ROMEROLAGUS Merriam

1896. *Romerolagus* MERRIAM, Proc. Biol. Soc. Washington, x, p. 173, December 29, 1896.

1898. *Lagomys* HERRERA, La Naturaleza, 2d ser., III, p. 80.

1899. *Romerolagus* MAJOR, Trans. Linn. Soc. London, 2d ser., VII, Zool., p. 514, November, 1899.

*Type*.—*Romerolagus nelsoni* MERRIAM.

*Geographical Distribution*.—West slope of Mount Popocatepetl, Mexico.

*Diagnosis*.—Externally, like *Pentalagus*; tail none; ears and hind feet short. Skull entirely leporine, palate long, postorbital process small, consisting of posterior limb only, nasals as in *Lepus*, auditory bullæ normal, equal to foramen magnum in size. First lower premolar divided into an anterior and a posterior portion by two reentrant angles, one extending from the external and the other from the internal face to the center of the tooth; anterior face of first lower premolar without reentrant angles. Sternum essentially as in *Ochotona*.

*Skull* (pls. LXXVIII, 1a, 1b, 1c).—The postorbital processes are small, of similar form and position to those of *Pronolagus* and *Caprolagus*, but relatively as well as absolutely smaller. The anterior angle is entirely lacking, so that the process appears as a triangle, one entire side of which is attached to the cranium. The second side is directed outward and somewhat forward. The third side is directed obliquely inward and backward, forming the outer boundary of a posterior notch.

The interparietal is present as a distinct, separate bone.

The bony palate in *Romerolagus* is very long, its least length nearly equaling four times that of  $M^1$  and equaled in proportional development only by *Pronolagus*. Its length measured half-way between the median line and the inner edge of the dental alveoli is very much greater than the greatest width of the two incisive foramina taken together, and also very much greater than the distance between the vertical plates of the palate bones or width of the choanæ. The

latter is not narrowed as in the case of *Oryctolagus*. The horizontal plates of the palate bones are extensively developed and form about half of the bony palate. The portion of the palate bone bordering the maxilla, caudad of the posterior edge of the bony palate, reaches its greatest development in *Romerolagus*, *Pentalagus*, and *Pronolagus*, about equally developed in each, where it helps to form the lateral posterior part of the roof of the mouth. The posterior palatine foramina are very large in *Romerolagus*; they are in the usual position at the anterior outer angles of the horizontal plates of the palate bones.

The zygoma of *Romerolagus* is very thick and deep. The antero-inferior angle is much enlarged and flares outward to a considerable degree. The foot-like extremity of the zygomatic process of the squamosal is moderately enlarged. The posterior free projecting extremity of the malar is large and long, being proportionally more so than in any of the other genera.

The audital bullæ show nothing peculiar, but the external auditory meatus is relatively larger than in the rest of the Leporidae, and its outline is oval instead of circular.

The fenestration of the maxilla is much reduced, about as it is in *Pronolagus* and *Limnolagus*.

The mandible of *Romerolagus* possesses wide ascending rami, which are nearly vertical instead of sloping backward as in other Leporidae. The angle is well developed and its edge is moderately rounded. The notch between the ascending ramus and the angular process is much larger than in any of the other genera.

*Teeth* (pl. xci, 3; fig. 44, 5).—The teeth of *Romerolagus* in a general way resemble those of *Pronolagus*. The first upper incisor has the groove rather deep but not filled with cement. The first upper molariform tooth presents the three usual reentrant angles on the anterior face, a deep median one and a shallower one on each side. The first lower molariform tooth has a broad shallow reentrant angle on the external surface of its anterior half. The main reentrant angle extends but half way across the tooth, while a corresponding reentrant angle comes in to meet this from the internal surface, both angles contributing to the division of the tooth into anterior and posterior portions.

The second, third, fourth, and fifth upper molariform teeth show reentrant angles that extend nearly across the teeth, but not quite so far as they do in *Pronolagus*. The internal third of the reentrant angles is rather wide; for the external two thirds, the adjacent sides are almost in contact. The posterior portions of the second,

third, and fourth lower molariform teeth have their lateral diameters equal to those of the anterior portions, like these teeth in *Pronolagus*. The last upper molar is small and narrowly elliptic in section. The last lower molar consists of the two usual portions, the anterior larger and elliptic, and the posterior smaller and circular.

*Vertebral Column.*—The cervical vertebræ (pl. XCII, 2) of *Romerolagus* belong to the shortened type. The costal process projects laterally from the centrum; its anterior and posterior spines are only moderately pronounced. The true transverse process is rather conspicuous and projects laterally from the fifth cervical onward through the rest of the series.

The length of a neural spine in the anterior part of the series of thoracic vertebræ is about twice the length of its centrum, relatively shorter than in other genera. Metapophyses are found in the last three vertebræ of this series. The tenth is the anticlinal vertebra.

The transverse processes of the lumbar vertebræ (pl. XCIV, 11) of *Romerolagus* are very characteristic. The processes are short and wide, the longest equaling the length of the centrum to which it is attached. The process on the first lumbar is very short and almost rudimentary. All the processes are wide and, in general, have triangular outlines. The base is broad, coming from the whole side of the centrum, so that the angle between the main axis of the process and the side of the centrum is completely filled up with thin bone. It is an exaggeration of the condition found in *Limnolagus*. The spinous processes of the lumbar vertebræ are low, triangular in outline. Anapophyses are very slightly developed. The first three lumbar vertebræ bear hypophyses, the first of which is the shortest; the second and third are nearly the same length, but the latter is a trifle longer.

The sacrum consists of the usual four vertebræ and does not differ in form from the sacra of the other genera of the Leporidae.

The caudal vertebræ of *Romerolagus* are only nine in number, this being the smallest number of any genus except *Brachylagus* which also has nine, and *Nesolagus* with eight. One vertebra is of the first form, like the last sacral, five are of the second form bearing more or less wing-like processes, the last three are merely centra without processes.

*Sternum and Ribs.*—The sternum (pl. XCVI, 1) of *Romerolagus* is very characteristic, being like that of *Ochotona*. The anterior portion of the presternum is very much expanded and flattened dorso-ventrally. To the outer posterior angles of this enlarged portion the first pair of ribs is attached. The rest of the presternum is long



and narrow, as it is throughout the other Leporidae, but devoid of any ventral keel. A slight ridge indicating a keel is seen on the ventral face of the expanded portion however. The mesosternum in general is very like the same structure in *Linnolagus*. The first and second segments are subequal, the third and fourth segments are subequal in length, but the fourth is broader. Both of the latter are relatively wider than they are in *Linnolagus* and as in that genus are firmly ankylosed. The xiphisternum is long and rather stout. It is but a little shorter than the whole mesosternum and decidedly longer than the presternum. The seventh pair of ribs does not meet the sternum, but articulates only with the cartilages of the sixth pair.

The ribs (pl. xciv, 8) of *Romerolagus* are very similar in structure to the ribs of *Pronolagus*; the only marked difference is that the poorly developed spine-like portion of the tubercles is last found on the sixth pair of ribs instead of on the seventh pair. The shafts of ribs are relatively narrow, and there is no indication of the wide expansion found in *Lepus*. Decidedly the widest part of the ribs is behind the spine.

*Shoulder Girdle and Upper Extremity.*—The ratio of the length of the humerus to the length of the clavicle (pl. xcvi, 1) in *Romerolagus* is 3.2, in *Oryctolagus* 3.15, in *Sylvilagus* 4, in *Ochotona* 2. In the skeletons representing the other genera the clavicles have been lost, due to faulty preparation. In the original account of the genus *Romerolagus*, the description reads (Merriam '96, p. 171): "The clavicle is complete and articulates directly with the sternum (fig. 33), a thing that never happens in the genus *Lepus*." In the present condition of the skeleton of *Romerolagus*, the clavicle has been cleaned from all its attachments. An examination of uncleaned skeletons of *Oryctolagus* and *Sylvilagus* showed that the clavicle did not articulate directly with the sternum. In the articulation of the clavicle *Romerolagus* resembles *Ochotona*, and not the other genera of the Leporidae.

The scapula (pl. xcvi, 9) of *Romerolagus* differs in form from the scapulæ of the other Leporidae, except *Pronolagus*, with which it has many points of similarity. It is long and narrow, its posterior border is practically straight instead of being concave, as in the other genera; its superior border is straight rather than convex. The distance between the antero-superior angle and the postero-superior angle is contained twice in the length of the scapula measured along the inner surface at the attachment of the spine. In the other genera with the exception of *Pronolagus* the distance be-

tween the two superior angles is contained but one and a half times in the scapular length.

There is little that is peculiar about the humerus. Like that of *Brachylagus* it is slenderer than in most of the other genera. The groove subtending the internal condyle is not well marked. The external condyloid ridge is better developed than in the other genera. The humerus of *Romerolagus* is distinctly longer than the radius.

Unlike the other genera, except *Oryctolagus* and especially *Pentalagus*, the radius of *Romerolagus* is slenderer than the ulna (pl. xcvi, 9); at its articular ends the usual degree of development takes place.

The carpus, the metacarpus, and the phalanges of *Romerolagus* are entirely similar in form and position to these same bones in any of the Leporidæ as detailed in the general account of the wrist and the hand (page 378).

*Pelvis and Lower Extremity.*—The os innominatum of *Romerolagus* closely resembles that of *Limnolagus*. The only marked difference, aside from its slenderer formation, is the more pronounced development of the short, blunt spine at the antero-ventral angle, and the straightness of the ventral edge of the ilium. The ilia are wide, but their antero-superior angles are not obliquely rounded off. The horizontal rami of the pubic bones slope backward to a greater extent than they do in other genera with the exception of *Limnolagus*.

The femur of *Romerolagus* is entirely similar to the same bone in any of the Leporidæ and needs no special mention.

The fusion of the fibula with tibia (pl. xcix, 9) in *Romerolagus* takes place at the middle of the latter bone, thus resembling *Ochotona*. In other genera of the Leporidæ, except *Pentalagus*, it occurs just above the middle. The tibia of *Romerolagus*, like that of *Limnolagus* and *Pentalagus*, is relatively heavier and also more curved than in the other genera, the inner surface of the lower part of its shaft being concave as in *Ochotona*.

The basal width of the metatarsus is contained twice in the length of the third metatarsal.

The combined lengths of the three phalanges approximately equal the length of the metatarsals to which they belong.

*Romerolagus nelsoni*, the only species of the genus, is represented by a single complete skeleton and several separate skulls.

*Romerolagus* is one of the best marked genera of the Leporidæ. Externally it appears much like *Pentalagus*.

The skull, as a whole, and in particular the postorbital processes and the palate, strongly suggests the skull of *Pronolagus*. The structure of the first lower premolar also associates *Romerolagus* with *Pronolagus* and with *Pentalagus* as well. Its external characters also associate it with *Pentalagus* but not with *Pronolagus*. In the shortness of its hind foot, *Romerolagus* approaches *Pentalagus* and *Ochotona*. The sternum of *Romerolagus* has almost exactly the same form as in *Ochotona*.

#### Genus NESOLAGUS Major

1897. *Caprolagus* TROUSSERT, Catalogus Mammalium, vol. 1, fasc. iii, p. 664.

1899. *Nesolagus* MAJOR, Trans. Linn. Soc. London, 2d ser., vii, Zool., p. 514, November, 1899.

1900. *Caprolagus* (in part) STONE, Proc. Acad. Nat. Sci. Philadelphia, 1900, p. 462.

*Type*.—*Nesolagus netscheri* (SCHLEGEL).

*Geographical Distribution*.—Sumatra.

*Diagnosis*.—Externally essentially as in *Caprolagus* (Schlegel, '80, pp. 61, 62). Reentrant angle of second upper cheek tooth extending little more than a third across the tooth, not crenated, but resembling the same tooth in *Brachylagus*. (Major, '99, pl. 37, fig. 17.)

No specimens of this interesting rabbit have been seen by the writer, and the following description is based on the figures given by Major and the description by Schlegel.

*Skull*.—Postorbital processes probably like those of *Romerolagus*, *Pronolagus*, *Caprolagus*, and *Pentalagus*.

The bony palate is long, the true palate bones forming about its posterior third, its length is greater than the width of the choanæ or incisive foramina. The incisive foramina are rather small, their sides approximately parallel, their greatest width less than the width of the choanæ. The choanæ are wide. The antero-inferior angle of the zygoma is enlarged. (Major, '99, pl. 39, fig. 38.)

*Teeth*.—The reentrant angle of the second upper molariform tooth extends but little more than a third of the distance across the tooth; its sides are not crenated. (Major, '99, pl. 37, fig. 17.)

*Vertebral Column*.—Sacro-caudal series of vertebra twelve (Schlegel, '80, p. 64). By considering four vertebræ as forming the sacrum, eight caudal vertebræ are left, a smaller number than is found in any other genus of the Leporidae.

*Sternum and Ribs* (pl. xcvi, 4).—Presternum considerably enlarged in its anterior third, to about the same extent as in

*Romerolagus*. Its different shape is shown in figs. 1 and 4, pl. xcvi. The mesosternum consists of four distinct segments, the first two subequal in length, compressed laterally; the third segment is slightly shorter, not laterally compressed; the fourth segment is very short and cartilaginous. The mesosternum, strangely enough, is quite unlike that of *Romerolagus*, and closely resembles the mesosternum of *Sylvilagus*. The xiphisternum is very short, much shorter than the presternum, its anterior end considerably enlarged, its posterior end not enlarged at all. Apparently only six pairs of ribs articulate directly with the sternum. (Major, '99, pl. 39, fig. 18.)

*Upper Extremity*.—Radius and ulna subequal. (Major, '99, pl. 38, fig. 28.)

*Species in the genus*.—One, *Nesolagus netscheri* (SCHLEGEL).

*Nesolagus* is apparently a well-marked genus, but unfortunately I have seen no examples of it. The general structure of its skull, radius, and ulna seems to associate it with *Caprolagus*. The anterior portion of its presternum is enlarged quite as in *Romerolagus* and *Ochotona*. The upper cheek teeth apparently resemble those of *Brachylagus* in the short non-crenate reentrant angles.

#### Genus CAPROLAGUS Blyth

1845. *Caprolagus* BLYTH, Journ. Asiatic Soc. Bengal, xiv, 1845, p. 247.

1863. *Lepus* BLYTH, Cat. Mam. Mus. Asiat. Soc. Calcutta, p. 133.

1867. *Carpolagus* GRAY, Ann. Mag. Nat. Hist., xx, 3d ser., p. 225.

1899. *Caprolagus* MAJOR, Trans. Linn. Soc. London, 2d ser., vii, Zool., p. 514, November, 1899.

1900. *Caprolagus* STONE, Proc. Acad. Nat. Sci. Philadelphia, 1900, p. 462.

*Type*.—*Caprolagus hispidus* (PEARSON).

*Geographical Distribution*.—Along the foot-hills of the Himalayas in northeastern India.

*Diagnosis*.—Fur harsh, ears much shorter than head, tail short. Skull short and heavy, rostrum stout, postorbital process represented by small posterior limb only. Teeth essentially as in *Lepus* except that the first lower premolar has two reentrant angles on anterior face and one on the internal face of the anterior portion of the tooth.

I have seen no members of this genus, and the following account has been taken from the published figures of the skull and teeth. (Blyth '45, Major '99.)

*Skull*.—The skull, as a whole, is rather short and heavy, moderately arched, rostrum short and stout, nasals about as wide in front as behind.

Postorbital process small, represented by the posterior limb only, which forms the outer border of a well-marked posterior notch.

The bony palate is long, its length equaling four times the length of  $M^1$ , its posterior third is formed by the horizontal plates of the palate bones. Its length is greater than the width of the choanæ, and is greater than the greatest width of the incisive foramina taken together.

The incisive foramina themselves are smaller than in any other genus except *Pentalagus*; their shape taken together is that of an elongated triangle.

The zygoma is deep, its posterior free extremity long. Its antero-inferior angle is not enlarged.

The audital bullæ are small, resembling those of *Pronolagus* and *Pentalagus*.

*Teeth*.—First upper incisor, groove on anterior face, deep, simple, and filled with cement (Major '99, p. 468, No. VIII). The first upper molariform tooth has the usual three reentrant angles on its anterior surface very deep, much as they are in *Pronolagus*; the sides of the angle are not crenated. The second, third, fourth, and fifth upper molariform teeth have each the usual deep reentrant angle on the internal face extending about four-fifths of the distance across each tooth. The sides of these reentrant angles are close together throughout their whole extent, and are strongly crenated in the first two of these teeth, moderately crenated in the third, and scarcely at all in the fourth. The last upper molar is very small, elliptic in outline, with a transverse diameter between a fourth and a fifth of the transverse diameter of the other upper jaw teeth.

The first lower molariform tooth is divided, by the usual deep reentrant angle from the external face, into an anterior and a posterior portion. The anterior face of the anterior portion has two narrow reentrant angles, and the external and internal faces of this portion have a single broad reentrant angle each. The second, third, and fourth lower molariform teeth are divided into the usual anterior and posterior portions by a well-marked reentrant angle extending from the external face across the tooth, the posterior limb of the angle being crenated. The posterior portion of the second lower molariform tooth has a transverse diameter about five-sixths the transverse diameter of the anterior portion; the transverse diameter of the posterior portion of the fourth lower molariform tooth is little more than half of the same dimension of the anterior portion of the tooth. The last lower molar is small, composed of a larger anterior portion, elliptic in section, and a smaller posterior portion, more nearly circu-

lar, which is very small in comparison with the anterior portion. (Major '99, pl. 36, fig. 33; pl. 37, fig. 23.)

*Upper Extremity*.—The radius and ulna are subequal in size, apparently shorter than they are in most of the Leporidae. (Major '99, p. 490, figs. XXXVI-XL.)

*Species in the genus*.—One, *Caprolagus hispidus* (PEARSON).

*Caprolagus* is apparently a well-marked genus of the Leporidae. It was the first member of the family to be separated as a genus distinct from *Lepus*. The structure of its teeth associate it with *Lepus*, *Sylvilagus*, and *Oryctolagus*, while the general shape of the skull make it appear related to *Nesolagus* and *Pentalagus*, as do also the external characters.

#### Genus PENTALAGUS new

1900. *Caprolagus* STONE, Proc. Acad. Nat. Sci. Philadelphia, p. 460.

*Type*.—*Pentalagus furnessi* (STONE).

*Geographical Distribution*.—Liu Kiu islands.

*Diagnosis*.—Ears and hind feet unusually short, similar to proportions in *Romerolagus*, pelage harsh, throat patch not well marked. Skull and teeth of leporine build, but molars  $\frac{2}{3}$  instead of  $\frac{3}{3}$ .

*Skull* (pl. LXXIX, 2a, 2b, 2c).—The skull as a whole is low and flat, not so much arched as is usual among the Leporidae, broad between the orbits, rostrum shorter and heavier than in the other Leporidae. Nasals very short and broad, as wide in front as behind; their most posterior point is on a line just anterior to the antero-inferior angle of the zygoma; in most of the other genera of the Leporidae, the nasals are on a line just posterior to the antero-inferior angle of the zygoma.

The postorbital process consists of the posterior limb only, as is the case with *Pronolagus*, *Caprolagus*, and *Romerolagus*. It is well developed, heavier and more blunt than in the genera just mentioned.

The sutures of the interparietal are obliterated.

The bony palate is long, being four times the length of  $M^1$ ; its posterior fourth is formed by the horizontal plates of the palate bones.

The incisive foramina are narrow, their sides approximately parallel, resembling in shape those of *Pronolagus*, but very much smaller. Their greatest width taken together is about half the length of the bony palate and much less than the width of the choanæ. The choanæ are wide, but their width is less than the length of the bony palate. The pharyngeal vault is low. The posterior palatine foramina are well developed and are situated at the outer anterior angles of the horizontal plates of the palate bones.

The zygoma is moderately heavy, its posterior free extremity moderately long, its antero-inferior angle slightly enlarged but considerably flared outward. The fossa, which is found usually in the Leporidae on the anterior surface of the antero-inferior angle, is lacking in *Pentalagus* as it also is in *Limnolagus*. The foot-like extremity of the zygomatic process is large.

The audital bullae are very small, being even more reduced in size than they are in *Pronolagus*. The external auditory meatus does not have the form of a rounded tube, but is an oval ring of bone closely applied to the side of the skull, just above and slightly behind the audital bulla. The paramastoid process of the exoccipital, which is in relation with the audital bulla posteriorly, is very large and heavy, and projects below the lowest point of the bulla about six millimeters. In all the other rabbits at hand, the paramastoid process projects not more than one or two millimeters below the bulla.

The sides of the maxilla are scarcely at all fenestrated, being pierced by a few small foramina only. The infraorbital foramen is large and distinct.

The premaxillae are relatively shorter than in the other genera and their nasal processes do not extend so far caudad.

The mandible of *Pentalagus* shows an exaggeration of the condition found in *Limnolagus*. The angular process is large and rounded, extends high up on the ascending ramus, which is relatively thick. The condyle has a long antero-posterior dimension. The notch between the condyle and the angular process is very short and shallow.

*Teeth* (pl. XCI, 7; fig. 44, 24).—*Pentalagus* differs from all the other known genera of the Leporidae in lacking the third upper molar.

The upper incisors are large and heavy, each with a broad sulcus on its anterior face, not filled with cement.

The first upper molariform tooth has the three usual reentrant angles, of which the middle and largest one is very deep and has its sides distinctly crenated. The second upper molariform tooth is the largest of the maxillary teeth; the third, fourth, and fifth are nearly subequal in size. The reentrant angles on all the teeth are well marked and extend almost completely across the tooth. The sides of these angles are almost in contact throughout their whole extent and more distinctly crenated than they are in the rest of the Leporidae.

The first lower molariform tooth is very long. It is divided into two portions, a narrower, longer, anterior one, and a broader, shorter, posterior one, by two well-marked reentrant angles, one from the external and the other from the internal face. The anterior portion

of the tooth has two reentrant angles on its anterior face, and one each on its internal and external faces. The second, third, and fourth lower molariform teeth have their posterior portions as well developed as their anterior portions, and the posterior limb of the reentrant angle which divides these teeth into two portions is very much more convoluted than in any of the other Leporidæ examined. The last lower molar has the appearance of a double cylinder, the anterior portion of which is larger and elliptic in outline, and the posterior portion smaller and more terete.

*Upper Extremity.*—The bones of the upper extremity, like those of the lower, are relatively shorter and stouter than in the other genera. The double trochlear surface of the humerus has its main portion very broad and shallow, while the outer portion is much reduced in size. The groove subtending the internal condyle is very shallow.

The radius and ulna (pl. xcvi, 10) are short, heavy bones, the ulna being the larger of the two. The radius is distinctly shorter than the humerus.

The carpal bones resemble those of the Leporidæ as described in the general account (page 378), but the pisiform is considerably reduced in size, and has almost the same form that it has in *Ochotona*.

The metacarpals are short and heavy, resembling those of *Ochotona*, and the basal width of the three middle ones is contained but one and a half times in the length of the middle metacarpal.

*Lower Extremity.*—The femur is very stout and heavy.

The tibia and fibula are also very stout and heavy, in marked contrast to the same bones in the other genera. As in the case of *Romerolagus* the fibula fuses with the tibia at its middle point (pl. xcix, 4).

The hind foot (pl. c, 4) is short and stout, the tarsal bones being relatively wider than in the other genera of the Leporidæ, having about the same general proportion as in the Ochotonidæ.

The metatarsals are especially short and heavy, and their basal width is contained but one and a half times in the length of the longest, as in the case of the Ochotonidæ.

*Pentalagus* is the most marked of any of the genera of the Leporidæ, the tooth formula, the structure of the teeth, the relative size of the radius and ulna, and the very short tarsus and metatarsus being peculiar to the genus and unlike anything in the rest of the family. A complete skeleton would probably show that it has still further points of differentiation from the typical leporine form.



Its general build of skull seems to associate it with *Caprolagus* and *Nesolagus*. But *Caprolagus* has typical leporine teeth and the upper cheek teeth of *Nesolagus* seem to resemble those of *Brachylagus*. In the structure of the first lower premolar, *Pentalagus*, *Romerolagus*, and *Pronolagus* are very similar.

The dental formula, the relation between radius and ulna, and the extremely short hind foot associate *Pentalagus* with *Ochotona*, but the general structure of its skull is entirely leporine.

## FAMILY OCHOTONIDÆ

### Genus OCHOTONA Link

1778. *Lepus* (in part) PALLAS, Glires, pp. 1-70.  
 1795. *Ochotona* LINK, Beyträge Naturgesch., 1, pt. ii, p. 74.  
 1800. *Lagomys* CUVIER, Leçons d'Anat. Comp., 1, Table.  
 1867. *Ogotoma* GRAY, Ann. Mag. Nat. Hist., xx, 3d ser., p. 220.  
 1867. *Lagomys* GRAY, Ann. Mag. Nat. Hist., xx, 3d ser., p. 220.  
 1897. *Ochotona* TROUESSART, Catalogus Mammalium, 1, fasc. ii, p. 645.  
 1899. *Lagomys* MAJOR, Trans. Linn. Soc. London, 2d ser., vii, Zool., p. 435, November, 1899.

*Type*.—*Ochotona ochotona* (PALLAS).

*Geographical Distribution*.—In the mountain ranges of eastern Europe, central Asia, Siberia, and the Boreal Zone of the mountains of western North America.

*Diagnosis*.—Same as for the family Ochotonidæ. Duplicidentate rodents without postorbital processes, and the second upper cheek tooth different in structure from the third. See also page 384.

*Skull* (pl. xc).—As a whole the skull of *Ochotona* is small, flat, not arched, brain case not rounded or inflated, rostrum short and moderately slender, the greatest width of the nasals being anterior and not posterior as in the case of the typical Leporidæ.

Postorbital processes are lacking.

The interparietal is present as a distinct bone.

The bony palate is very short, and the incisive foramina in front and the choanæ behind are separated only by a very narrow bridge of bone. The sutures of the horizontal plates of the palate bones and of the horizontal plates of the maxilla are obliterated in adult skulls. Young individuals show that more than half of the bony palate is formed by the horizontal plates of the palate bones. The horizontal plate of the palate is largely developed between the dental alveoli and the outer border of the choanæ, each such portion of the horizontal plate of the palate bone being approximately equal to the width of the choanæ.

The incisive foramina are variously shaped; they may have an elongated, triangular form, as in *Ochotona royllii*, but more usually they are divided into two portions—a smaller anterior one just behind the upper incisors, and a larger, rather pyriform one, just anterior to the bony palate—by the uniting to a greater or less extent of the posterior ventral portions of the two premaxillary bones.

The zygoma is moderately heavy; at its antero-inferior angle is a well-marked tubercle; its posterior free extremity is very long.

The maxilla of *Ochotona* is not fenestrated as it is in the Leporidae. Instead there is a single large, roughly triangular opening in the upper part of the nasal portion of the maxilla. In *Ochotona royllii*, however, the triangular opening is more elongated than in the other species, and just inferior to it there is a very slight amount of fenestration.

The mandible of *Ochotona* has a very wide ascending ramus and long condyle; the notch between the ascending ramus and the angular process is large. No groove or thin plate of bone is found on the anterior surface of the ascending ramus of the mandible, as in the Leporidae, but a prominent tubercle occurs there which is lacking in the latter family. The mental foramen is situated on the side of the horizontal ramus, directly under the last lower molar.

*Teeth* (pl. xci, 2: fig. 44, 25.)—The first upper incisors of *Ochotona* have each a single, simple groove. Their cutting edge is very sharp; that portion external to the groove is much produced downward, the internal portion only moderately so produced. In this manner an unequally sided V-like notch is seen on the front cutting edge of each tooth, with the groove at the point of the V.

The second upper incisors are small slender teeth placed directly behind the first. The lower incisors, a single pair, are longer, slenderer, and more pointed than the corresponding teeth in *Lepus* and its allies.

The first upper premolar is small, with a single reentrant angle on the inner half of the anterior face.

The second upper premolar has a reentrant angle on its anterior face, extending to the middle of the tooth and thence toward the outer edge. There is also a broad, shallow angle on the internal face of this tooth.

The three remaining upper jaw teeth possess each a single reentrant angle on the internal face, extending all the distance across the tooth, very much like the reentrant angles of the Leporidae, but without any crenation. The last tooth has a projecting loop of enamel, from its posterior aspect, thus differing from the two teeth immediately in front of it.

The first lower premolar much resembles the anterior half of the first lower premolar of *Lepus*. It has two reentrant angles on the external face and one on the internal.

The second, third, and fourth mandibular cheek teeth of *Ochotona* are quite like the corresponding teeth of the Leporidae, but the division into anterior and posterior portions is more marked and the two portions are entirely subequal.

The last lower molar is small, irregularly oval in outline, its pointed end being toward the external side. A posterior portion to this tooth is completely lacking.

*Vertebral Column.*—The cervical vertebrae (pl. XCII, 1) of the Ochotonidae have the same general characteristics as in the Leporidae. They are decidedly shortened antero-posteriorly, the laminae of the posterior ones being very narrow. This shortening involves the axis but not the atlas. The latter has the free extremities of the transverse processes moderately expanded. The costo-transverse process of the third, fourth, and fifth cervicals are placed more obliquely to the axis of the vertebral column than the same processes in the Leporidae. In the sixth they become horizontal as they do in the hares. The transverse process of the seventh cervical differs from the same process on the same vertebra in the Leporidae in not being pierced by a costo-transverse or vertebral foramen.

The thoracic vertebrae of the Ochotonidae are seventeen in number. The first twelve of the thoracic vertebrae, in *Ochotona*, are exactly homologous with the twelve thoracic vertebrae of the Leporidae. The arrangement of the facets for the heads and the tubercles of the ribs is entirely similar. The five remaining rib-bearing vertebrae of *Ochotona* are practically indistinguishable from one another, as well as from the twelfth, except by the slightly greater size of each succeeding vertebra.

The spinous processes are relatively shorter in *Ochotona*, and this is especially true in the posterior thoracic region from the twelfth onward, where the spines are all low and slightly inclined forward. Each neural spine of these posterior thoracic vertebrae arises by a broad base from the whole length of the neural arch; the free extremity of the process is nearly as broad as the base, the posterior edge being slightly concave.

That part of the transverse process of the thoracic vertebra which articulates with the tubercle of the rib is of the same form in the two families. Associated with this transverse process in *Ochotona* are the metapophysis and the anapophysis. Both of these processes are first seen on the third thoracic as mere tubercles. The anapo-

physis grows larger on each succeeding vertebra, attaining its greatest size on the last thoracic. From the eleventh thoracic onward the anapophysis is a well-marked process, directed upward, backward, and outward. The metapophysis remains little more than a tubercle until the tenth thoracic vertebra is reached, where it is a well-marked process. On the eleventh it is slightly larger and on the twelfth still larger, closely associated with the prezygopophysis. The metapophysis scarcely increases in size through the rest of the series and continues closely associated with the prezygopophysis throughout.

No ventral spines or hypophyses are found on any of the vertebræ. Some of the posterior thoracic have a slight ventral ridge, which is also found on all the lumbar vertebræ.

There are five lumbar vertebræ (pl. xciv, 10) in *Ochotona*, each of which is compact, with the processes broad and closely applied to body. The neural process is low, with the free edge as long as the whole length of the vertebra and parallel with its axis. The metapophysis is well developed and is more closely associated with the prezygopophysis than it is in the Leporidæ. Anapophyses are well developed on the first and second lumbar vertebræ and are a direct continuation of the thoracic series of anapophyses. These processes are slightly indicated on the third lumbar vertebra, after which point they disappear. The transverse process is little more than a tubercle on the first and second lumbar vertebræ, but on the third and fourth it is a wide quadrilateral plate of bone coming from the whole side of the vertebræ, sloping downward and outward. The transverse process of the fifth and last lumbar is a trifle longer than the other transverse processes and only about half as wide, the narrowing taking place chiefly at the expense of the posterior half of the process. There are no hypophyses, but all the lumbar vertebræ, as is the case of those lumbar vertebræ of the Leporidæ which do not bear ventral spines, possess a median ventral ridge.

The sacrum in the pikas is long and narrow, its greatest breadth being contained in its length about twice. The lateral masses that are attached to the ilia have sides that are nearly parallel. The neural spines, so distinct and conspicuous on the sacra of the Leporidæ, are reduced in the Ochotonidæ to form a low dorsal ridge, the spines having fused with one another. The number of vertebræ entering into the formation of the sacrum of the Ochotonidæ is four, the same as in the Leporidæ.

The caudal vertebræ in *Ochotona* are eight in number in all the skeletons at hand except one, which has nine. In the three American specimens, the first caudal is somewhat narrowed; the next two are

slightly wider, with faint indications of lateral projections; the rest of the series consists of short, flattened bodies. The single Asiatic skeleton has mainly the same character of the caudals, but the individual vertebræ are relatively wider throughout.

*Sternum and Ribs* (pls. xcvi, 2; xciv, 9).—The material for making generalizations of the sterna of *Ochotona* is far from satisfactory. Among four skeletons but one is fully adult and there is a certain amount of variation among them. It may be that more material would show that there are two or three different types of sterna in the Ochotonidæ. Aside from a few minor details the sternum of the only adult *Ochotona* at hand, No. 91,188, is almost exactly like the sternum of *Romerolagus*. The expanded position of the manubrium is less developed in *Ochotona* than in *Romerolagus*, and rather triangular in outline instead of pentagonal. In other respects the two sterna are similar. The presternum is nearly as long as the mesosternum and slightly longer than the xiphisternum.

The mesosternum of *Ochotona* is, in general, very similar to that of *Romerolagus*. The first and second segments are subequal in length, the second, however, being broader. The third segment is the longest and broadest of the mesosternum. The fourth segment is the shortest and nearly as broad as the third. Both the third and fourth mesosternal segments are completely ankylosed as they are in *Romerolagus* and *Limnolagus*.

The xiphisternum is considerably expanded at the proximal end but the distal extremity is not much enlarged. It is decidedly shorter than the presternum.

The seventh rib is attached, along with the sixth rib, to the sternum at the point of union of the meso- and xiphi-sternum.

No. 30,990 *Ochotona saxatilis*, from Idaho, is very similar to the above; it is young, however, and the third and fourth pieces of the mesosternum are not yet fused.

No. 49,620, from Oregon, has the entire mesosternum narrow, and its last two segments separate.

No. 49,500 *Ochotona ladacensis*, has the enlarged portion of the presternum less expanded, the mesosternum is relatively longer and decidedly narrower than is the mesosternum of *O. saxatilis*, the third and fourth mesosternal segments are not fused. The mesosternum, as a whole, bears considerable resemblance to some of the mesosterna of *Sylvilagus*. The xiphisternum is rather short.

In *Ochotona* there are seventeen pairs of ribs, of which the first seven are attached to the sternum by means of costal cartilages; the

last seven, or about that number, have no ventral attachments, while the intermediate three pairs are attached to the costal cartilages of the ribs in front. The ribs are all slender and weak compared with the ribs of the Leporidae, and none of them possesses well-developed spine-like tubercles, but between the heads and tubercles the anterior ribs are rather broad and heavy.

*Shoulder Girdle and Upper Extremity.*—In *Ochotona*, the clavicle (pl. xcvi, 2) is well developed; its outer end is enlarged, flattened, and connected by a ligament to the greater tuberosity of the humerus. The inner end articulates directly with the extreme anterior portion of the presternum.

The scapula (pl. xcvi, 5) has the general outline of a right-angled triangle with the right angle very much rounded off. The acromion process is very long and slender and about three times the length of the actual scapular spine. The metacromion is well developed. The posterior border of the scapula is long and concave; the superior border is relatively long and much rounded, so that it gradually passes into the anterior border. The distance between the antero-superior and postero-superior angles is contained a little more than once in the length of the scapula, taken along the attachment of the spine.

The humerus of *Ochotona* is in general very much like the same bone in *Lepus* and its allies. The head of the bone is rather more globular, and the bicapital groove does not encroach on its anterior surface. The anterior tuberosity does not project above the head of the bone, so that the latter point is its highest part. When viewed from the side, the head of the humerus is seen to project rather backward, so as to form a sort of hook with the shaft of the bone. The double trochlear surface, at the distal end of the bone, is rather wide and shallow. The groove subtending the internal condyle is poorly developed.

The bones of the forearm (pl. xcvi, 11) in *Ochotona* are similar to the forearm bones of *Pentalagus* (page 430). The ulna is distinctly larger than the radius throughout its whole extent. The outer portion of the distal extremity of the ulna is prolonged downward into a convex articular surface which fits into a corresponding concavity formed by the cuneiform and pisiform bones. There is also a concave facet just internal to this projection which articulates with a corresponding convexity on the cuneiform.

The structure of the carpus of *Ochotona* is best understood by an examination of the figures (page 379). Compared with the carpus of *Lepus* and its allies the dorso-palmar depth of the pisiform is

relatively small, the lunare narrow, the internal half of the cuneiform larger, which presents a well-developed convex facet for articulation with the ulna, as mentioned above. The os centrale is quite large, and not flask-shaped. The os magnum is rather small. A small os vesalianum is present.

The metacarpus and phalanges of *Ochotona* are quite like the same structures in *Lepus*. The second and fourth metacarpals are nearly as long as the third. The width of the three middle metacarpals is contained about one and a half times in the length of the third metacarpal.

*Pelvis and Lower Extremity.*—The most striking feature of the pelvis of *Ochotona* is the absence of the symphysis pubis. The pubic bones are widely separated from one another but are connected by a ligament. As none of the few available skeletons are sexed, it is barely possible that this character is sexual. The os innominatum is rather long and slender, the ilium rather thick, its ventral third separated from the dorsal two-thirds by a well marked ridge, which terminates anteriorly and ventrally in a well-marked, recurved, pointed spine. The thyroid foramen is ovoid, its narrow end directed forward toward the acetabulum. The horizontal ramus of the pubis is very short, the descending ramus long, directed obliquely backward and downward.

The femur of *Ochotona* has the same general character that it has in *Lepus*, but is relatively thicker and heavier. The third trochanter is much reduced in size, the lesser trochanter relatively larger. The fossa behind the great trochanter is not so deep as in *Lepus*. The length of the femur is a trifle less than that of the tibia.

The tibia and fibula (pl. XCIX, 6, 7) of *Ochotona* are similar in all respects, except in absolute size, to these bones in *Romerolagus*. The fibula fuses with the tibia at the middle of the latter bone. The inner surface of the lower part of the shaft of the tibia is concave.

The tarsus of *Ochotona* is generally like that of *Lepus*. The middle cuneiform, however, is fused with the base of the second metatarsal. The basal width of the metatarsals is contained one and a half times in the greatest length of the metatarsals. There is a large sesamoid bone at the plantar surface of the base of the fifth metatarsal. This bone is lacking in the Leporidae, but is represented by a prominent tubercle on the fifth metatarsal in the same situation.

The skulls of *Ochotona* available for study are a heterogeneous lot, capable of being placed in three distinct groups, described below as subgenera.

**Subgenus OCHOTONA Link**

1795. *Ochotona* LINK, Beyträge Naturgesch., I, pt. II, p. 74.

1867. *Ogotoma* GRAY, Ann. Mag. Nat. Hist., XX, 3d ser., p. 220.

*Type*.—*Ochotona ochotona* (PALLAS).

*Geographical Distribution*.—Mountains of central Asia.

*Diagnosis and Description*.—Brain-case rather flattened, resembling that in subgenus *Pika*. Skull (pl. XC, 84,062) itself rather strongly arched, especially between the orbits. Interorbital region very narrow and pinched up. Incisive foramina constricted into two unequal portions as they are in subgenus *Pika*.

Represented by several skulls of *Ochotona ladacensis*. The figures published by Büchner, show that *O. koslowi* also belongs to this subgenus.

**Subgenus CONOTHOA new**

*Type*.—*Ochotona roylli* OGILBY.

*Geographical Distribution*.—Mountains of central Asia.

*Diagnosis and Description*.—Brain-case rather rounded, whole skull (pl. XC, 30,814) moderately arched from before backward, rostrum relatively long, its origin less abrupt than in the other subgenera. A small oval foramen, between one and two millimeters long, is found in the antero-superior part of each frontal bone; interorbital region moderately wide. The opening in the maxilla is elongated triangular; just beneath this large opening there is a small amount of fenestration. The incisive foramina together are triangular in outline, usually not constricted into an anterior and posterior portion.

This subgenus is represented by several skulls of *Ochotona roylli*. The figures of *O. erythrotis*, published by Büchner, show that it undoubtedly belongs in this subgenus, although the incisive foramina are constricted into two portions.

**Subgenus PIKA Lacépède**

1799. *Pika* LACÉPÈDE, Tableau de Divisions de Mammifères, p. 9.

*Type*.—*Ochotona alpina* (CUVIER).

*Geographical Distribution*.—Same as for the genus.

*Diagnosis and Description*.—Brain-case and whole skull (pl. XC, 66,678) very flat, interorbital region rather broad and flat, not pinched up or arched. No foramina in the anterior part of the frontals. Opening in the maxilla roundly triangular, single. Incisive foramina constricted into two unequal portions.

*Ochotona alpina* illustrated by Waterhouse (pl. II), and all the American species belong to this subgenus.



## VIII. GEOGRAPHICAL DISTRIBUTION

The family Leporidae is widely distributed. Members of it are found in every portion of the world except the general regions embraced by Australia and neighboring islands, and by Madagascar and neighboring islands. In the terms of zoogeographers they are found throughout the Arctogæic realm (Lydekker '96) with the exception of the Malagasy region, and one genus is found in the Neogæic realm. No member of the family is found in the Notogæic realm, nor in the Malagasy region of the Arctogæic realm.

The genus *Lepus* has the same general distribution that the family has, except that no members so far as known are found in the Neogæic realm. This genus is found most abundantly in the Holarctic region.

The subgenus *Lepus* is mainly confined to the Holarctic region, but in North America one species, *Lepus campestris*, extends into the Sonoran region (Lydekker '96) or Arid Transition faunal area (Merriam '98).

The subgenus *Pæcilolagus*, so far as known, is found in that portion of North America which belongs to the Holarctic region, the Canadian, Hudsonian, and Transition zones.

The subgenus *Macrotolagus* is chiefly confined to the western arid portion of the Sonoran region of Lydekker or the arid portion of Merriam's Austral region embracing the Upper and Lower Sonoran.

The genus *Sylvilagus* is restricted entirely to the New World, where it extends throughout the Sonoran region of the Arctogæic realm of Lydekker, and southward more or less extensively throughout the Neogæic realm, or it may be said to occur throughout the Transition zone of Merriam and all the zones southward.

*Brachylagus* has a rather small distribution in the Upper Austral, called Upper Sonoran faunal area, in southern Idaho, northern Nevada and California, and eastern Oregon and Washington.

*Limnolagus* is found, in general, throughout the Austroriparian faunal area, occupying the greater part of the South Atlantic and Gulf states.

The genus *Oryctolagus* occurs in southern and western Europe and northern Africa, in general, the southwestern portion of Lydekker's Holarctic region in the Old World.

The genus *Pronolagus*, so far as known, is confined to the southern portion of Africa or the Ethiopian region.

The remaining genera of the Leporidae contain but a single species each, and have a very limited distribution.

*Caprolagus* is found along the foothills of the Himalayas in north-eastern India.

*Nesolagus* is found only in Sumatra.

*Romerolagus* is known only from Mount Popocatepetl, Mexico.

*Pentalagus* is known only from the Liu Kiu islands, south of Japan.

The family Ochotonidæ has a much less extensive distribution than the Leporidae. Members of it are found in the Canadian zone of the Rocky mountains of western North America. They also occur in the mountain ranges of eastern Europe, central Asia, and in Siberia. They are thus confined to the Holarctic region of the Arcticæic realm.

#### IX. BIBLIOGRAPHY

The following bibliography gives the titles of the works which are referred to in, and have been of most service in the preparation of, the present paper, with the exception of those that are mentioned in the tables of synonymy, or incidentally in the text, where full references are given.

**Baird, S. F., '57.**

Mammals of North America, 1857. pp. 572-620, pls. LVI-LIX.

The following groups of the genus *Lepus* are recognized, designated by letters: A, corresponds to the genus *Lepus* exclusive of the subgenus *Macrotolagus*; B, corresponding to the subgenus *Macrotolagus*; C, to the genus *Oryctolagus*; D, to the subgenus *Sylvilagus*; E, to the subgenus *Microlagus*, and F, to the genus *Limnolagus*.

Excellent figures of skulls of *Lepus*, *Sylvilagus*, *Macrotolagus* and *Limnolagus* are given.

**Blyth, Edward, '45.**

Description of *Caprolagus*, a new genus of Leporine Mammalia.

Journal of Asiatic Society of Bengal, XIV, 1845, pp. 247-249.

*Caprolagus* proposed as a genus to include *Lepus hispidus* PEARSON.

Figures of the skull, dorsal, ventral and lateral views are given.

**Büchner, Eug., '94.**

Wissenschaftliche Resultate der von N. M. Przewalski nach Central-Asien Reisen Zool. Theil, Band I. Säugethiere. St. Petersburg, 1894.

Contains excellent photographic reproductions of the skulls of *Ochotona* (*Ochotona*) *ladacensis*, *Ochotona* (*Ochotona*) *koslowi*, *Ochotona* (*Conothoa*) *crythrotis*, *Ochotona* (*Pika*) *daurica*, *Lepus oistolus*, and *Lepus pallipes*, on plates XXIV and XXV.

**Flower, William Henry, and Lydekker, Richard, '91.**

Mammals, living and extinct, London, 1891, pp. 491-495.

Brief descriptions of the two families of the Duplicidentata, Lagomyidæ, and Leporidae, each with a single existing genus, *Lagomys* and *Lepus*, are given.

**Gray, J. E., '67.**

Notes on the skulls of Hares (Leporidae) and Picas (Lagomyidae) in the British Museum. *Annals and Magazine of Natural History*, 3d series, vol. xx, 1867, pp. 219-225.

Lagomyidae divided into two genera: *Ogotoma* and *Lagomys*.

Leporidae divided into the following genera: *Hydrolagus*, *Sylvilagus*, *Eulagus*, *Lepus*, *Tapeti*, *Cuniculus*, *Carpolagus*.

**Krause, W., '84.**

Die Anatomie des Kaninchens in topographischer und operativer Rücksicht, Zweite Auflage, 1884, pp. 1-383.

It contains a complete anatomy of the common rabbit *Oryctolagus cuniculus*; pp. 36-46, general osteology; pp. 75 to 135, a detailed description of all the bones of the rabbit, illustrated by woodcuts, figs. 28 to 64; pp. 197-199, embracing figs. 80-82, devoted to the teeth. In the introduction, pp. 1-35, many of the differences between the hares *Lepus* and the rabbits *Oryctolagus* are pointed out, figs. 3-13. The skulls and bones of the forearm of each are figured.

**Lilljeborg, '74.**

Sveriges och Norges Rygggradsdjur, I, 1874.

Describes *Lepus* with two subgenera, true *Lepus* represented by *timidus*, *Oryctolagus* (new name to replace Gray's *Cuniculus*) for *Lepus cuniculus*. The cranial characters of the two subgenera are carefully set forth.

**Lydekker, Richard, '96.**

A geographical History of Mammals, 1896.

A work of 400 pages with a map of the mammalian geographical realms and regions in the front.

**Major, C. I. Forsyth, '99.**

On Fossil and Recent Lagomorpha. *Transactions of the Linnean Society of London*, 2d ser., VII, Zoology, November, 1899, pp. 433-530, plates 36-39.

An elaborate account of recent and fossil forms, with excellent figures, especially of the teeth. The characters for the groups are not well defined and are rather obscured in the mass of general discussion.

**Mearns, Edgar A., '96.**

Preliminary description of a new subgenus and six new species and subspecies of hares from the Mexican border of the United States. *Proc. U. S. Nat. Museum*, XVIII, pp. 551-565, June 24, 1896.

*Macrotolagus* described as a new subgenus of *Lepus*. Diagnoses of *Hydrolagus*, *Sylvilagus*, and *Macrotolagus* given.

**Merriam, C. Hart, '96.**

*Romerolagus nelsoni*, a new genus and species of rabbit from Mt. Popocatepetl, Mexico. *Proc. Biol. Soc. Washington*, x, pp. 169-174, December 29, 1896.

The genus *Romerolagus* is described. Its sternum is figured.

**Merriam, C. Hart, '98.**

Life and Crop Zones of the United States. *Bull. No. 10*, U. S. Dept. Agric., Div. of Biol. Survey, 1898, pp. 1-79.

Map of the life zones of the United States in front.

**Miller, Gerrit S., Jr., 1900.**

A new subgenus for *Lepus idahoensis*. Proc. Biol. Soc. Washington, XIII, p. 157, June 13, 1900.

*Brachylagus* is proposed as a subgenus for *Lepus (Brachylagus) idahoensis* MERRIAM, and some of its characters are defined.

**Miller, Gerrit S., Jr., and Rehn, James A. G., '01.**

Systematic Results of the Study of North American Land Mammals to the close of the year 1900. Proc. Boston Soc. Nat. Hist., xxx, No. 1, pp. 175-190, December 27, 1901.

It gives a complete list of all the North American Duplicitenta known up to the close of 1900 and places them in their several genera and subgenera, according to the views of modern workers.

**Pallas, 1778.**

Novæ Species Quadrupedum e Glirium Ordine. 1778, pp. 1-70, pls. I-IV.

The hares, rabbits and pikas are placed in one genus *Lepus*.

The external and internal anatomy of *Ochotona pusilla*, *alpina*, and *ogotona* is given with considerable detail. Figures of the skull and a figure of the entire skeleton of *pusilla* are given. *Lepus variabilis* and *L. tolai* are also described at some length.

**Palmer, T. S., '04.**

North American Fauna No. 23. Index Generum Mammalium. January 23, 1904.

On pp. 850-851, a list of the generic and subgeneric terms that have been applied to the Leporidae; on p. 860, those that have been applied to the Ochotonidae. In the body of this invaluable work, each of these terms is treated by itself.

**Schlegel, H., '80.**

On an anomalous species of Hare discovered in the Isle of Sumatra; *Lepus netscheri*. Notes from the Leyden Museum, II, 1880, pp. 59-65, February.

A description of external characters and a few skeletal characters is given. No figures.

**Stone, Witmer, 1900.**

Description of a new rabbit from the Liu Kiu islands, and a new flying squirrel from Borneo. Proc. Acad. Nat. Sci. Philadelphia, 1900, pp. 460-463.

External and cranial characters of *Pentalagus furnessi* (STONE) described. *Pentalagus* not recognized as distinct but considered a part of *Caprolagus*, which is regarded as a good genus.

**Trouessart, E.-L., '97.**

Catalogus Mammalium, Vol. I, fasc. iii, 1897, pp. 644-664.

A list, with references, of all known hares, rabbits, and pikas is given. It aims to be a compilation of what has been published in a systematic way on the subject, up to its date of publication, together with the geographic distribution.

*Microlagus* is named on p. 660 as a subgenus for *Lepus cinerascens* ALLEN.

**Waterhouse, G. R., '48.**

A Natural History of the Mammalia, Vol. II, Rodentia, 1848, pp. 9-147, pls. I and II.

Contains an excellent account of the structure and characters of the two families Leporidae and Ochotonidae. All the species known at that time are described. On plate II good figures are given of the skulls of *Lepus timidus* and *Ochotona alpina*.

EXPLANATION OF PLATES

PLATE LXXIV (About four-fifths natural size)

- 1 and 1a. *Lepus (Macrotolagus) alleni*, No. 59,223, Sonora, Mexico.  
2 and 2a. *Lepus (Lepus) europæus*, No. 105,831, Switzerland.

PLATE LXXV (About five-sixths natural size)

1. *Lepus (Pacilolagus) americanus dalli*, No. 36,209, Alaska.  
2. *Lepus (Macrotolagus) alleni*, No. 59,223, Sonora, Mexico.  
3. *Lepus (Lepus) europæus*, No. 105,831, Switzerland.

PLATE LXXVI (About five-sixths natural size)

- 1, 4. *Lepus (Pacilolagus) americanus dalli*, No. 36,209, Alaska.  
2, 5. *Oryctolagus cuniculus*, No. 49,645, Germany.  
3, 6. *Limnolagus palustris*, No. 2,089, Society Hill, South Carolina.  
7, 8. *Sylvilagus (Sylvilagus) floridanus transitionalis*, No. 49,624, Monroe county, New York.  
9, 10. *Sylvilagus (Microlagus) bachmani*, No. 44,416, San Luis Obispo, California.

PLATE LXXVII (About five-sixths natural size)

1. *Sylvilagus (Microlagus) bachmani*, No. 44,416, San Luis Obispo, California.  
2. *Sylvilagus (Sylvilagus) floridanus transitionalis*, No. 49,634, Monroe county, New York.  
3. *Pronolagus crassicaudatus*, No. 22,972, South Africa.  
4. *Limnolagus palustris*, No. 2,089, Society Hill, South Carolina.  
5. *Oryctolagus cuniculus*, No. 49,645, Germany.

PLATE LXXVIII (Natural size)

- 1a, 1b, 1c. *Romerolagus nelsoni*, No. 57,954, Mt. Popocatepetl, Mexico.  
2a, 2b. *Pronolagus crassicaudatus*, No. 22,972, South Africa.  
3. *Brachylagus idahoensis*, No. 93,696, Ione valley, Idaho.

PLATE LXXIX (Natural size)

1. *Brachylagus idahoensis*, No. 93,696, Ione valley, Idaho.  
2a, 2b, 2c. *Pentalagus furnessi*, No. 5,583 (Wistar Institute), Liu Kiu islands.

## PLATES LXXX, LXXXI (About three-fifths natural size)

1. *Lepus (Lepus) othus*, No. 15,878, St. Michaels, Alaska.
2. *Lepus (Lepus) europæus*, No. 1,857, Bavaria.
3. *Lepus (Lepus) tschuktschorum*, No. 86,459, Petropaulski, Kamschatka.
4. *Lepus (Lepus) variabilis*, No. 37,137, Sweden.
5. *Lepus (Lepus) campestris*, No. 49,623, Kansas.
6. *Lepus (Lepus) labradorius*, No. 23,132, type, Labrador.
7. *Lepus (Lepus) grænlandicus*, No. 114,849, Bache peninsula, Greenland.
8. *Lepus (Lepus) varronis*, No. 105,834, Switzerland.

## PLATES LXXXII, LXXXIII (About two-thirds natural size)

1. *Lepus (Macrotolagus) alleni*, No. 59,292, Sonoyta, Mexico.
2. *Lepus (Macrotolagus) merriami*, No. 84,646, Fort Clark, Texas.
3. *Lepus (Macrotolagus) asellus*, No. 36,009, type, San Luis Potosi, Mexico.
4. *Lepus (Macrotolagus) callotis*, No. 35,678, Guadalajara, Mexico.
5. *Lepus (Macrotolagus) californicus*, No. 60,867, U. S. and Mexican boundary line at Pacific ocean.
6. *Lepus (Macrotolagus) texianus cremicus*, No. 63,119, U. S. and Mexican boundary line, monument No. 77.
7. *Lepus (Macrotolagus) texianus*, No. 63,118, U. S. and Mexican boundary line, monument No. 64.
8. *Lepus (Macrotolagus) gailardi*, No. 35,709, White Water, Chihuahua, Mexico.

## PLATES LXXXIV, LXXXV (About five-eighths natural size)

1. *Lepus ruficaudatus*, No. 38,039, India.
2. *Lepus ochropus*, No. 34,735, Kilima-njaro, Africa.
3. *Lepus hypsibius*, No. 84,076, Rupshu, Ladak.
4. *Lepus tibetanus*, No. 62,126, Ladak.
5. *Lepus yarkandensis*, No. 62,132, Yarkand river, eastern Turkestan.
6. *Lepus (Pæcilolagus) washingtonii*, No. 6,865, Washington.
7. *Lepus (Pæcilolagus) americanus dalli*, No. 36,209, Alaska.
8. *Lepus (Pæcilolagus) americanus struthopus*, No. 23,123, Labrador.
9. *Lepus (Pæcilolagus) americanus virginianus*, No. 101,844, Massachusetts.
10. *Lepus (Pæcilolagus) americanus macfarlani*, No. 14,467, type, Fort Anderson, British America.

## PLATES LXXXVI, LXXXVII (Nine-fourteenths natural size)

1. *Sylvilagus (Sylvilagus) floridanus mallurus*, No. 1,227, District of Columbia.
2. *Sylvilagus (Sylvilagus) floridanus yucatanicus*, No. 37,772, type, Merida, Yucatan.
3. *Sylvilagus (Sylvilagus) floridanus mearnsi*, No. 22,409, Illinois.
4. *Sylvilagus (Sylvilagus) truci*, No. 112,787, Mexico.
5. *Sylvilagus (Sylvilagus) margarita*, No. 63,217, type, Margarita island.
6. *Sylvilagus (Sylvilagus) subcinctus*, No. 35,663, Hacienda El Molino, Mexico.
7. *Sylvilagus (Sylvilagus) brasiliensis gabbi*, No. 37,794, type, Talamanca, Costa Rica.

8. *Sylvilagus (Sylvilagus) paraguensis*, No. 121,423, Sapucay, Paraguay.
9. *Sylvilagus (Sylvilagus) arizona*, No. 58,863, Fort Lowell, Arizona.
10. *Sylvilagus (Sylvilagus) auduboni*, No. 60,921, Coast Range mountains, U. S. and Mexican boundary line.
11. *Sylvilagus (Microlagus) cinerascens*, No. 60,871, Tecate river, U. S. and Mexican boundary line.
12. *Sylvilagus (Microlagus) bachmani*, No. 35,131, Nicasio, California.
13. *Sylvilagus (Microlagus) bachmani ubericolor*, No. 35,371, type, Beaverton, Oregon.

## PLATES LXXXVIII, LXXXIX (About five-eighths natural size)

1. *Oryctolagus cuniculus*, domestic, Belgian hare, No. 105,402.
2. *Oryctolagus cuniculus*, common domestic, No. 62,704.
3. *Oryctolagus cuniculus*, common domestic, No. 36,831.
4. *Oryctolagus cuniculus*, wild, No. 3,124, England.
5. *Oryctolagus cuniculus*, wild, No. 49,645, Germany.
6. *Limnolagus paludicola*, No. 64,029, Kissimmee, Florida.
7. *Limnolagus palustris*, No. 2,089, Society Hill, South Carolina.
8. *Limnolagus aquaticus*, No. 3,779, Warren county, Mississippi.
9. *Limnolagus aquaticus*, No. 84,109, Mississippi.
10. *Limnolagus atwateri*, No. 97,031, Richmond, Texas.

## PLATE XC (Natural size)

1. *Ochotona (Ochotona) ladacensis*, No. 84,063, Ladak, central Asia.
2. *Ochotona (Pika) princeps*, No. 66,678, Nelson, British Columbia.
3. *Ochotona (Conothoa) roylei*, No. 36,814, Baltistan.

## PLATE XCI (Enlarged three times)

## LOWER AND UPPER CHEEK TEETH, RIGHT SIDE

1. *Brachylagus idahoensis*, No. 23,104, Goose lake, California.
2. *Ochotona ladacensis*, No. 84,062, Ladak, central Asia.
3. *Romerolagus nelsoni*, No. 57,954, Mt. Popocatepetl, Mexico.
4. *Limnolagus paludicola*, No. 64,029, Kissimmee, Florida.
5. *Oryctolagus cuniculus*, No. 49,648, England.
6. *Lepus campestris*, No. 61,367, Madison, Minnesota.
7. *Pentalagus furnessi*, No. 5,583 (Wistar Institute), Liu Kiu islands.
8. *Pronolagus crassicaudatus*, No. 22,972, South Africa.
9. *Sylvilagus floridanus*, No. 49,588, Florida.

## PLATE XCII (Natural size except Figure 1, which is enlarged twice)

## VENTRAL VIEWS OF CERVICAL VERTEBRÆ

1. *Ochotona saxatilis*, No. 91,188, Cabinet mountains, Idaho.
2. *Romerolagus nelsoni*, No. 57,954, Mt. Popocatepetl, Mexico.
3. *Brachylagus idahoensis*, No. 93,595, Lone valley, Idaho.
4. *Limnolagus paludicola*, No. 49,580, Florida.
5. *Sylvilagus floridanus*, No. 49,587, Florida.
6. *Oryctolagus cuniculus*, No. 49,645, Germany.
7. *Lepus (Lepus) campestris*, No. 49,623, Kansas.
8. *Lepus (Pavilolagus) americanus virginianus*, No. 969, New York.
9. *Lepus (Macrotolagus) texianus*, No. 94,198, Newark valley, Nevada.
10. *Pronolagus crassicaudatus*, No. 22,972, South Africa.

## PLATE XCIII (Natural size)

## LUMBAR VERTEBRÆ, SEEN FROM THE SIDE.

1. *Lepus (Lepus) campestris*, No. 49,622, Nebraska.
2. *Lepus (Pacilogus) americanus virginianus*, No. 969, New York.
3. *Pronolagus crassicaudatus* No. 22,972, South Africa.
4. *Oryctolagus cuniculus*, No. 49,648, England.
5. *Oryctolagus cuniculus*, lop-ear, domestic, No. 49,386.

## PLATE XCIV (Natural size, except 9 and 10 enlarged twice)

## RIBS AND LUMBAR VERTEBRÆ

1. *Lepus texianus*, No. 94,198, Newark valley, Nevada.
2. *Lepus campestris*, No. 49,623, Kansas.
3. *Pronolagus crassicaudatus*, No. 22,972, South Africa.
4. *Oryctolagus cuniculus*, No. 49,645, Germany.
5. *Sylvilagus floridanus mallurus*, No. 89,514, Four-mile Run, Virginia.
6. *Limnolagus palustris*, No. 49,580, Florida.
7. *Brachylagus idahoensis*, No. 93,595, Ione valley, Idaho.
8. *Romerolagus nelsoni*, No. 57,954, Mt. Popocatepetl, Mexico.
- 9 and 10. *Ochotona saxatilis*, No. 91,188, Cabinet mountains, Idaho.
11. *Romerolagus nelsoni*, No. 57,954, Mt. Popocatepetl, Mexico.
12. *Brachylagus idahoensis*, No. 93,595, Ione valley, Idaho.
13. *Limnolagus paludicola*, No. 49,580, Florida.
14. *Sylvilagus floridanus mallurus*, No. 89,514, Four-mile Run, Virginia.

## PLATE XCV (Natural size)

## STERNA AND COSTAL CARTILAGES, VENTRAL VIEW.

1. *Brachylagus idahoensis*, No. 93,595, Ione valley, Idaho.
2. *Sylvilagus floridanus*, No. 49,587, Florida—clavicles shown.
3. *Lepus (Macrotolagus) texianus*, No. 94,198, Newark valley, Nevada.
4. *Lepus (Lepus) campestris*, No. 49,622, Nebraska.
5. *Oryctolagus cuniculus*, No. 49,645, Germany—clavicles shown.

## PLATE XCVI

## STERNA AND COSTAL CARTILAGES, VENTRAL VIEW.

1. *Romerolagus nelsoni*, No. 57,954, Mt. Popocatepetl, Mexico—clavicles shown. Natural size.
2. *Ochotona saxatilis*, No. 91,188, Cabinet mountains, Idaho—clavicles shown. Twice natural size.
3. *Pronolagus crassicaudatus*, No. 22,972, South Africa, natural size.
4. *Nesolagus netscheri*, copied from Pl. 39, fig. 18, Major '99.
5. *Limnolagus paludicola*, No. 49,580, Florida, natural size.

## PLATE XCVII (Natural size)

## SCAPULÆ.

1. *Lepus (Lepus) campestris*, No. 49,623, Kansas.
2. *Lepus (Macrotolagus) texianus*, No. 94,198, Newark valley, Idaho.
3. *Oryctolagus cuniculus*, No. 49,648, England.
4. *Pronolagus crassicaudatus*, No. 22,972, South Africa.
5. *Ochotona saxatilis*, No. 91,188, Cabinet mountains, Idaho.
6. *Limnolagus paludicola*, No. 49,580, Florida.



7. *Sylvilagus floridanus*, No. 49,588, Florida.
8. *Brachylagus idahoensis*, No. 93,696, Ione valley, Idaho.
9. *Romerolagus nelsoni*, No. 57,954, Mt. Popocatepetl, Mexico.

## PLATE XCVIII (Natural size)

## BONES OF THE FORE ARM

1. *Lepus (Lepus) campestris*, No. 49,623, Kansas.
2. *Lepus (Macrotolagus) texianus*, No. 94,198, Newark valley, Nevada.
3. *Lepus (Pacilolagus) americanus virginianus*, No. 969, New York.
4. *Sylvilagus floridanus*, No. 49,586, Florida.
5. *Limnolagus paludicola*, No. 49,580, Florida.
6. *Brachylagus idahoensis*, No. 93,696, Ione valley, Idaho.
7. *Pronolagus crassicaudatus*, No. 22,972, South Africa.
8. *Oryctolagus cuniculus*, No. 49,648, England.
9. *Romerolagus nelsoni*, No. 57,954, Mt. Popocatepetl, Mexico.
10. *Pentalagus furnessi*, No. 5,583 (Wistar Institute), Liu Kiu islands.
11. *Ochotona saxatilis*, No. 91,188, Cabinet mountains, Idaho.

## PLATE XCIX (Natural size)

## BONES OF THE LEG

1. *Lepus campestris*, No. 49,622, Nebraska.
2. *Oryctolagus cuniculus*, No. 49,645, Germany.
3. *Pronolagus crassicaudatus*, No. 22,972, South Africa.
4. *Pentalagus furnessi*, No. 5,583 (Wistar Institute), Liu Kiu islands.
5. *Sylvilagus floridanus*, No. 49,586, Florida.
6. *Ochotona saxatilis*, No. 91,188, Cabinet mountains, Idaho.
7. *Ochotona ladacensis*, No. 49,500, Ladak, central Asia.
8. *Brachylagus idahoensis*, No. 93,696, Ione valley, Idaho.
9. *Romerolagus nelsoni*, No. 57,954, Mt. Popocatepetl, Mexico.
10. *Limnolagus paludicola*, No. 49,580, Florida.

## PLATE C (Natural size)

## HIND FEET

1. *Ochotona ladacensis*, No. 49,500, Ladak, central Asia.
2. *Romerolagus nelsoni*, No. 57,954, Mt. Popocatepetl, Mexico.
3. *Brachylagus idahoensis*, No. 93,696, Ione valley, Idaho.
4. *Pentalagus furnessi*, No. 5,583 (Wistar Institute), Liu Kiu islands.
5. *Limnolagus paludicola*, No. 49,580, Florida.
6. *Lepus campestris*, No. 49,623, Nebraska.
7. *Pronolagus crassicaudatus*, No. 22,972, South Africa.
8. *Oryctolagus cuniculus*, No. 49,645, Germany.
9. *Sylvilagus floridanus*, No. 49,586, Florida.

## NOTES

### PALEONTOLOGICAL COLLECTIONS FROM EUROPE

Mr. Charles Schuchert, Assistant Curator of the Division of Stratigraphic Paleontology in the National Museum, left Washington, June 24, 1903, for an extended trip through Europe, returning November 2. His object was to study in the field and in the museums the Ordovician, Silurian, and Devonian faunas and their stratigraphic sequence, to obtain large and instructive materials for the Louisiana Purchase Exposition, and to represent the National Museum at the Ninth International Geological Congress held at Vienna during the latter part of August.

He spent six days in collecting Silurian fossils on Gotland, an island province of Sweden replete with well-preserved fossils. Nearly all the localities are along the sea-shore and the cliffs known as the Klint. The late Professor Lindström's collector, Mr. Anton Florin, assisted in gathering the fossils.

Mr. Schuchert next devoted sixteen days to a study of the museums in St. Petersburg and to making Ordovician collections in the Baltic region west of Reval. The preservation of these fossils is excellent and collecting here is as good as about Cincinnati. Nearly all the localities in Estland are on baronial estates, and every facility was extended by the owners for making the collecting both easy and profitable. During this time Mr. Schuchert was directed and instructed by Professor Dr. Frederick von Schmidt of the Imperial Academy, and by Dr. August von Mickwitz of Reval. Both of these gentlemen also presented much fine material, so that a representative collection of the varied trilobites, cephalopods, brachiopods, and cystids are now in the National Museum.

From Reval Mr. Schuchert traveled to Berlin, Dresden, and Prag, where the various natural-history museums were visited and the paleontologic collections examined. With Dr. Jaroslav Perner a day was spent in the Moldau valley, above Prag, in examining a number of Barrande's localities for fossils of the Silurian and Devonian strata. Another day was spent in collecting Konieprusian fossils at Barrande's famous locality, Zlaty Kun, near Beraun, and some good material was purchased of Mr. Fritsch at Prag. At München two days were spent in an examination of the great collections made under the direction of the late Professor Zittel.



1, 2, *PENTACRINUS SUBANGULARIS* FROM GERMANY; 3, *ÆSIOCRINUS* FROM KANSAS CITY, MISSOURI. (Size of No. 2, 45 x 17 inches.)



Another day was spent at Eichstätt, Bavaria, in examining the "Solenhofen" quarries, from which region so many interesting Jurassic fossils have been procured. More than one hundred specimens were purchased of Mr. Fritz Ehrensberger, among which are some large cuttle-fish bones or pens of *Leptoteuthis gigas*, one of which is 38 inches and another 24 inches in length. Arrangements also were made for the purchase of several large fishes and a fine *Rhamphorhynchus*, showing both wing and tail membranes.

Twelve days were spent in collecting Devonian fossils in the Eifel, around Coblenz on the Rhine, and in Hessen-Nassau. In the first and last-named places Mr. Schuchert had as his instructor Professor Dr. E. Kayser of Marburg, and about Coblenz, Dr. O. Follmann. Although the season was very wet and collecting consequently much interrupted, a representative collection of Middle Devonian fossils of the Calceola shales was obtained.

At Bonn the large natural-history establishment of Dr. F. Krantz was visited and a number of interesting fossils purchased. Two of these are large Lias Holzmaden crinoids, *Pentacrinus subangularis*, illustrated in plate CI. A *Cerithium giganteum*, more than 24 inches in length, was also procured. From another dealer and paleontologist, Dr. B. Stürtz, an excellent series of Lower Devonian starfishes and crinoids was obtained, making the National Museum collection of these rarities second only to that of the British Museum.

Two days were spent in collecting Cretaceous bryozoa about Maastricht, in southern Holland, a locality prolific in these fossils. At Brussels the splendid paleontologic collections of the Royal Museum were examined, chief among which is the dinosaur *Iguanodon bernissartensis*, to which an entire room is devoted. In this museum is also the De Koninck collection of Carboniferous invertebrates. A day each was given to examining the Carboniferous stratigraphy about Visé and Tournai, and small collections were procured from local dealers.

At London considerable time was devoted to examining the great and well-exhibited fossil collections of the British Museum of Natural History, and also the collection of the Geological Survey. From Robert Damon, of Weymouth, England, was purchased a lot of fine fossils, one of which is an excellent Jurassic slab of *Trigonia*, while another slab is replete with crinoid heads of *Pentacrinus fossilis* and is illustrated in plate CII.

As a result of this trip sixteen boxes of European fossils have arrived at the National Museum—a good nucleus for comparative studies with the American faunas.

#### A NOTEWORTHY CRINOID

Frank Springer, Esq., of East Las Vegas, New Mexico, recently presented to the United States National Museum a slab, nearly five feet square, covered with the Uinta crinoid (*Uintacrinus socialis* GRINNELL). This slab is a piece of one mass originally fifty feet long by twenty feet wide, and was collected by Mr. Springer in the upper part of the Niobrara foraminiferal chalk (Upper Cretaceous), near Elkader, Logan county, Kansas. The slab shown in plate CIII has about 140 bodies or crowns of this crinoid, but originally there were several times as many, because the slab, three-eighths of an inch in thickness, is composed of them. This ten-rayed crinoid was a free floating species, and at times probably held itself to foreign objects by its long, slender arms. One specimen on this slab preserves several complete arms having a length of 36 inches, but the largest individuals are estimated to have had an arm-spread of 8 feet 4 inches, "a size far exceeding that of any other known crinoid, recent or fossil."

CHARLES SCHUCHERT.

#### SHIELDS FROM WESTERN SUMATRA

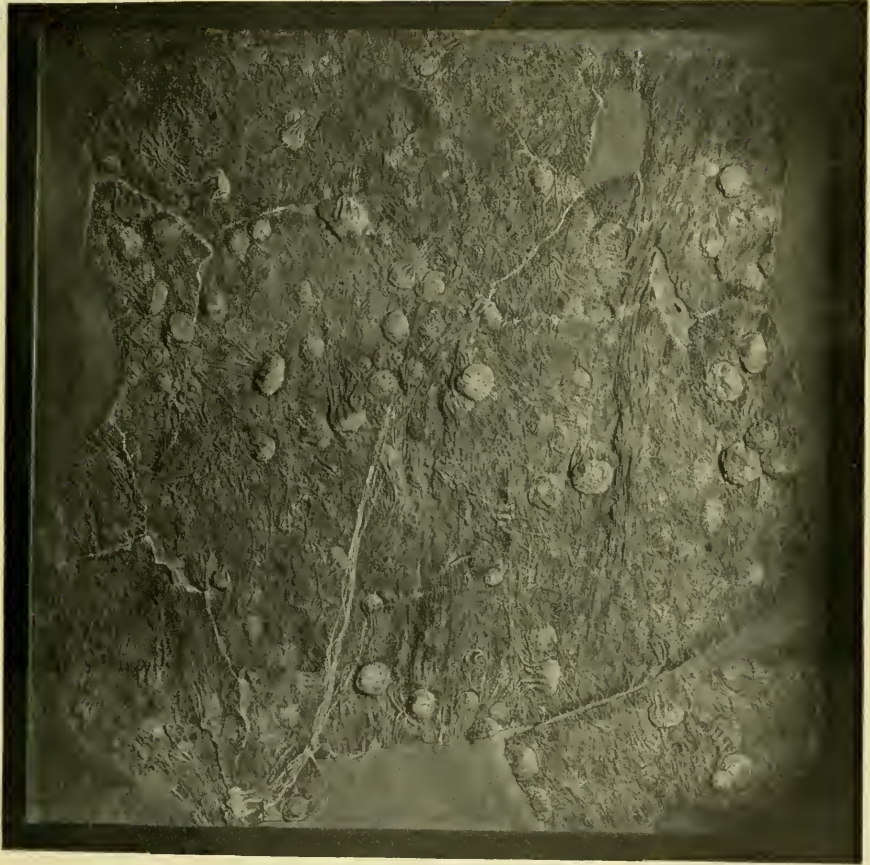
Dr. W. L. Abbott has recently sent to the National Museum a number of wooden shields from Nias and Batu islands, lying off the western coast of Sumatra. Each of these shields is carved from a single piece of the strong light wood of the oil tree (*Dipterocarpus*), and consists of an elliptic body, concavo-convex in transverse section, with projecting club-like ends. The shield is strengthened by a midrib on the exterior, which is expanded into a boss in which the hand-grip is excavated. The thin wings on each side of the midrib are strengthened at intervals with a horizontal sewing, of bark cord or rattan strips, through perforations. This sewing is done with two pairs of cords parted to each side at the start; each pair is then twisted between the perforations, one free end from each pair is passed through the hole in opposite directions, and twisted with the remaining cord as before. This results in what seems to be a continuous two-strand cord extending evenly on both sides of the shield, the holes being hidden. By this sewing the thin wings of the shield are made very strong with but little increase



*PENTACRINUS FOSSILIS* FROM LYME REGIS, ENGLAND. (Size 4 x 2 feet.)







*UINTACRINUS SOCIALIS* FROM KANSAS. (Size nearly 5 x 5 feet.)



of weight. This treatment has not been previously described. Sometimes bands of rattan are passed across the faces of the shield and held in place by a cross-sewing through holes. On the upper projection of the shield, the midrib, and the edges, thin wedge-shaped pieces of iron have been inserted as a protection against cutting weapons. The Nias shield shows plainly the development of this defensive weapon from the club, and it is evidently still mainly used for parrying, though it has widened out under the influence of the spear and of cut-and-thrust weapons. The solid projecting ends and the midrib preserve the vestiges of the club, from which it has been derived. The average Nias shield measures 41 inches in length and  $9\frac{1}{4}$  inches in width.

WALTER HOUGH.

#### EARTHQUAKE IN PERU

The Department of State has courteously sent to the Smithsonian Institution the following despatch from United States Consul A. L. M. Gottschalk, dated Callao, Peru, March 5, 1904:

"I have the honor to report that an earthquake-shock of much severity was felt in Lima and Callao on Friday, March 4, at about 5:20 A.M. Oscillation was from southwest to northeast; duration variously estimated at from 30 to 50 seconds. Considerable damage of the minor sort was done to public edifices, churches chiefly, in Lima and Callao, in the way of broken statues, fallen cornices, etc. One of the towers of the cathedral of Lima is said to be badly cracked and may have to be torn down. During the vibrations church bells were tolled and for a few moments general consternation prevailed. I believe that only one life was lost, though a number of persons were more or less injured by falling plaster, etc. No house is without broken crockery and bric-a-brac, and at the Consulate at Callao all the furniture, including an iron safe, was shifted about an inch. The shock was preceded, at 12 M., by a seismic movement so slight as to be barely perceptible.

"At Callao greater damage was done owing to the ramshackle nature of buildings, a number of which (small dwellings) collapsed. There was no appreciable damage to wharves or shipping. Passengers aboard the S. S. *Mexico* entering port state that the shock was felt by them 'as if the ship had suddenly struck a rock.'

"At Chorrillos, a fashionable coast resort near by, some damage was done to houses and to the sea wall. President Candamo's villa there was in part destroyed during the family's occupancy.

"Canete and Chincha to the south, and all the ports north of us as far as Trujillo, report feeling the shock severely. News is not at present obtainable from Cerro de Pasco, the railway having suffered from land-slides.

"No tidal wave accompanied the shock here.

"The earthquake of March 4, 1904, is generally admitted to have been the severest felt in Peru since 1868. The last phenomenon of the kind experienced here was on September 20, 1897, and was of a much lighter nature."

#### A RECENT VISIT TO THE COFFEE MOUNTAINS OF LIBERIA

The following extract from a despatch, dated March 2, 1904, from Consul General Ernest Lyon at Monrovia, Liberia, has been officially communicated to the Smithsonian Institution by the Department of State:

"We left Carysburg Sunday afternoon at 3:30 for the Coffee mountains, a place of interest to all tourists who come to Liberia. The distance to the principal mountain in the range is about twenty-five miles. The range received its name because the aborigines found coffee growing on its summits. The path to the mountains lies through the dense forest which abounds in rich timbers and interesting flora. The timber consists of a variety of valuable woods, some of which are the following: red and gray mahogany, four varieties of oak, cedar, rosewood, mangrove, whitegum, burrwood, mulberry, sassawood, brimstone, redpeach, pepperwood, white-mangrove, persimmon, ironwood, poplar, and greasypeach. If it will be of interest to the department, this office will furnish samples of some of the valuable woods.

"The flora is not only interesting but possesses value for medicinal purposes. The forest for one hundred miles whither I have been is lined with a variety of these valuable herbs. There is scarcely a leaf or berry or root, according to the intelligent native medicine-man who was paid to accompany us, which cannot be utilized as a medicine for the diseases common to Africa; for instance, the corsa is a species of leaves which may be used as a purgative or for the cure of ulcers; the corsa is used also for weakness and imbecility as well as for a general stimulant; and there are many others, as the Xmas-leaf, cherrybark, alum, senna, etc., each of which has its medicinal use.

"The next day at 11 A.M. we reached the foot of the principal mountain. It was impossible to reach the top, but after a climb

of two hours' duration we reached a portion of the summit. From this lofty peak, several hundred feet above the level of the sea, we could see the capital city, Monrovia, and many of the towns on the St. Paul river, lying apparently at its base. The gigantic size of the trees so impressed us that we took actual measurement of one of them, which we found to be from 25 to 35 feet in circumference, and we judge the trunk extended without a limb from 100 to 125 feet high. This abundance of timber suggests the possible wealth of the lumber industry in this country. Strange this mountain is still unexplored, and its summit is still the home of wild and dangerous animals. Here also is the center of the hopes of the gold concessionist. After many experiments they have been led to believe that the vein which will ultimately reward their endeavors lies somewhere around these mountains. A number of mining experts are now there attempting to locate this vein."

#### THE SCOTIA ANTARCTIC EXPEDITION

Through the courtesy of the Honorable, the Secretary of State, the Smithsonian Institution is enabled to present the following brief but interesting report on the progress of the *Scotia* Antarctic Expedition, which has been submitted by the Honorable John Barrett, United States Minister to Argentina:

"In view of its probable interest in scientific circles, I have the honor to submit the following brief report of the trip of the *Scotia* Scientific Expedition to the Antarctic regions, the data for which have just been given me by the leader of the expedition, Mr. W. S. Bruce, F.R.S.E.

"The expedition was organized by public subscription in Scotland and received very material assistance from all the leading Scottish scientific societies, especially the Royal Scottish Geographical Society, the Royal Society of Edinburgh, and the Perthshire Natural Science Society, as well as from several departments of the British Government which supplied some valuable instruments and charts.

"The object of the expedition was a study of meteorology and oceanography, both physical and biological, in the Antarctic regions. The expedition was also to lend assistance, in case of necessity, to Dr. Nordenskjöld of the Swedish expedition, but no assistance was necessary in view of the fact that relief had already been sent to the Antarctic by the Argentine and Swedish Governments.

"The personnel of the expedition was as follows: Mr. W. S. Bruce, F.R.S.G.S., Leader; Mr. R. C. Mossman, F.R.S.E., Meteorologist;

Dr. J. H. H. Pirie, Surgeon and Geologist; Dr. R. N. R. Brown, Botanist; Mr. D. W. Wilton, Zoologist; Mr. Allister Ross, Taxidermist; Mr. W. A. Cuthbertson, Artist.

"The *Scotia* left Scotland on November 2, 1902, and, after stops at Madeira and the Falklands for coal, met the ice on February 2, 1903, in  $59^{\circ}$  S. lat.,  $40^{\circ}$  long. W. (approximate). She then visited the South Orkney islands and thence made a cruise of about 5,000 miles to the south and east between longitude  $16^{\circ}$  W. and  $45^{\circ}$  W. and as far south as  $70^{\circ} 25'$ . In this region a deep sea was found of an almost uniform depth of 2,500 fathoms, the deepest sounding being 2,739 fathoms. Trawls were lowered several times in these depths and brought up fishes, star-fishes, sea-lilies, sea-cucumbers, sponges, crustaceans, shell-fish, and smaller organisms. Temperatures, salinities, currents, and the color of the sea were observed at all depths from the surface to the bottom.

"This cruise ended on March 25, 1903, the *Scotia* having covered about 4,000 miles of previously unexplored sea. The ship anchored in a bay in Laurie island, South Orkneys, since named Scotia bay, and before the end of the month was beset and frozen in for the winter, not being released until November 24, 1903. During this time a house was built and a meteorological observatory (first class) was established, as well as a magnetic observatory. Throughout the winter baited sea-traps were set through a hole in the ice which secured a large number of zoological specimens and no less than 2,000 pounds of fish for food. Every day, except when severe weather prevented, a dredge was dragged by means of a continuous rope and two holes cut through the ice and cleared from day to day. Four expeditions were made during the spring, three with sledges and one with boats for purposes of hydrographic and land survey. As a result of these expeditions and of survey work in the vicinity of the ship a 25-inches-to-the-mile map of Scotia bay and a 2-inches-to-the-mile map of the rest of Laurie island and the adjacent islands were prepared. During this local survey about 500 soundings were taken—almost every one of them involving cutting through ice from 3 to 5 feet thick.

With the exception of the chief engineer, who died of heart-disease, all the members of the expedition and crew enjoyed excellent health. Mr. Bruce attributes this largely to the fact that, in preference to preserved meats, penguins and fish and, in the spring, penguin eggs in liberal quantities were eaten.

"The *Scotia* left the South Orkneys on November 27, 1903, and arrived at Port Stanley December 2 and at Buenos Aires December

24. While she was in dry-dock here I visited her, together with Mr. Ames, the Secretary of Legation, by invitation of Mr. Bruce and of her commander, Captain Robertson, and found her stoutly built, splendidly equipped, and full to overflowing of various scientific specimens.

"Meteorological and magnetic observations have been continued at Scotia bay under the superintendence of Mr. Mossman. Mr. Bruce has offered to the Argentine government the use of this station and his supplies there and passage thither by the *Scotia* for four scientists if the government will maintain the station during the coming year and undertake the relief of those stationed there at the end of that time.

"The *Scotia* will leave for the South Orkneys on or about the 15th instant and, after a few days at Scotia bay, will proceed to the south and east for further deep-sea explorations, returning, in all probability, by way of Cape Town and reaching Scotland toward the end of June."

#### RECENT PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

CONTINUED FROM LIST OF JANUARY, 1904, IN PUBLICATION No. 1419

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1443	PETTIGREW, J. B. Various modes of flight.....	R. 1867	.05
1444	ALDRICH, T. M. Catalogue of N. A. Diptera ( <i>In press</i> ) .....		
1445	Smithsonian Miscellaneous Collections ( <i>Quarterly Issue</i> ), vol. XLV, Parts 3 and 4 (containing 1446-1456) .....	M.C. XLVI	
1446	LANGLEY, S. P. Personal equation in transit observations ( <i>Quarterly Issue</i> ).....	M.C. XLV	1.00
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