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·SMITHSONIAN·INSTITVTION·WASHINGTON·1846·

Smithsonian Miscellaneous Collections

VOLUME L

(QUARTERLY ISSUE, VOLUME IV)

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

No. 1789

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
1908

WASHINGTON, D. C.
PRESS OF JUDD & DETWEILER, INC.
1908

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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 branches, and especially for the publication of reports of a preliminary nature.

CHARLES D. WALCOTT,
Secretary of the Smithsonian Institution.

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SMITHSONIAN

MISCELLANEOUS COLLECTIONS

VOL. IV QUARTERLY ISSUE PART 1

NOTES ON SOME UPPER CRETACEOUS VOLUTIDÆ, WITH DESCRIPTIONS OF NEW SPECIES AND A REVISION OF THE GROUPS TO WHICH THEY BELONG [1]

By WILLIAM HEALEY DALL

While engaged in the study of the Tertiary fauna of Coos Bay, Oregon, it became necessary for me to investigate the systematic position of certain forms of Volutes which were contained in it. Their relations to certain Upper Cretaceous forms had been assumed and they had even been referred to the same genus. An investigation of the question was made possible by the kindness of Dr. T. W. Stanton, of the U. S. Geological Survey, in whose official province the Cretaceous forms belong and who placed at my disposition for study all the material which he had brought together.[2]

An examination of these fossils showed that a larger number of species existed than had been supposed, and that the Upper Cretaceous seems to have been marked by an efflorescence of related large Volutes in all parts of the world where the fauna of that period has been explored. A comparison of these groups of species with each other and with our American forms, a revision of their systematic arrangement, a description of the new species and the application of new names to those forms which had been described in the literature under names not properly applicable to them, have been attempted in the present paper.

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[1] Published by permission of the Director of the United States Geological Survey.

[2] I am also under obligations to Dr. J. F. Whiteaves, of the Dominion Geological Survey, and Dr. Ralph Arnold, of the U. S. Geological Survey, for the loan of material and other courtesies.

Family VOLUTIDÆ

The inception of the Volutidæ, Fasciolariidæ, and Turbinellidæ appears to have begun in the Cretaceous from a stock of Prosobranchiate Gastropods apparently also the progenitors of another series in which plaits were not developed on the pillar. I have elsewhere described the dynamic principles concerned in the development of plaits in spiral shells of any genus,[1] and it is only necessary to recall the fact that the horizontality or obliquity of the plaits is a function of the plane of enrollment of the whorls, more or less modified by the shape of the aperture and canal. Other things being equal, the shell whose whorls are coiled most nearly in the same plane will have the most nearly horizontal plaits.

To small forms which illustrate the inception of plaits upon the pillar, as would synthetic types of the family groups above referred to, Meek gave the name of *Piestochilus*.[2] Another form, called by him *Mesorhytis*, and still persisting in the deep-sea fauna, is referred by many paleontologists to the genus *Mitra*, and may be more closely related to the Mitridæ than to the group we are discussing.

The forms which appear early, and in which the generic type seems hardly settled into equilibrium, are usually lumped by authors under the inappropriate name of *Volutilithes;* the true *Volutilithes* having a different development, a membranous instead of a shelly protoconch, and first appearing in the Eocene. The antithetic genus, *Plejona* (Bolten) Dall, is more closely related to these Cretaceous types from which it is no doubt descended. The species which may be properly associated with *Plejona* among these early mutable types are those which have an excavated columella with an anterior heavy plait, behind which may be several smaller and less distinct plications.

The forms which are developing in the direction of the Volutidæ of the future and which first show the Volutoid characteristics appear in the middle Cretaceous, and it is this line of evolution which this discussion is intended to follow.

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[1] Am. Naturalist, XXVIII, Nov., 1894, pp. 909-914, figs. 1-3; see also Trans. Wagner Inst., III., p. 58, 1890, *et seq.*

[2] Smithsonian Check list N. Am. Cret. Foss., p. 22, 1864. Since the species of *Piestocheilus* named by Meek come from high up in the Cretaceous, while the most nearly related American Volutes come from the Pugnellus sandstone (Turonian?), it is not intended to regard the former otherwise than as later representatives of Mid-Cretaceous forms which, through the imperfection of the geological record, are yet unknown to us, but presumably resembled *Piestocheilus.*

The forms developed somewhat later in all the upper Cretaceous areas which have been explored have a notable family likeness, together with features which in each case lend a certain local facies to the species of each special local fauna. We find also that among the species which make up the group in each fauna are usually repeated certain types of form, each of which probably corresponds to some special conditions which make it fittest to survive, while each faunal locality probably includes about the same groups of conditions each of which impinges upon a particular species or group of species more effectively than on the others. To illustrate the case metaphorically, it seems as if each faunal district resembles a temple containing a number of niches of different shapes, in which the species of each genus or family resident in the district are obliged by the pressure of the environment and the action of natural selection to take their places, those which fail to conform to some one of these protective and formative niches being unable to survive.

Whether the types preserved by these conditions, with their pronounced analogies of form and ornament, should be classed by dynamically developed characters, when it is probable that their genetic connections are closer with the local group rather than with their analogues in other districts and exotic groups, is a subject which naturally opens up the whole question of the proper relations between classification and nearness of genetic ties. Those systematists who claim that degrees of genetic relationship should govern classification, to the exclusion of all other factors, will have no difficulty in deciding the question. Others, with perhaps greater appreciation of the complexity of organic relations and who believe that classification is a means by which we may obtain an end and not an end in itself, must hesitate longer. Without losing sight of genetic connections in a broad sense, in the present state of science at least, it is more convenient, and not less suggestive to the student, to recognize in the system the community of response to the environment at a particular stage of evolution, as well as the more hypothetical connections believed or suspected to conform to the "line" of descent. It may even be doubted whether response to the environment is not in many cases the more potent factor in evolutionary progress than the tendencies inherited from an ancestral reticulum; for it is certain that no organism is of purely, or even potentially, linear descent for any long series of generations.

The possibility of migration complicates the question somewhat, though in geological horizons believed to be nearly contemporaneous and representing equivalent stages of evolution it is probable that migrations play a very minor part.

Among the features common to the Gastropoda of both the upper Cretaceous and Eocene, one is quite conspicuous. It is the frequency with which forms of diverse lineage develop a tendency to produce a coat of enamel over the whole surface of the shell, often very profusely, in species belonging to groups which in the recent fauna have not the habit. As examples, reference may be made to such forms as *Volutomorpha, Liopeplum, Liomelon, Athleta,* and *Psilocochlis,* while numerous others will occur to the reader.

We may now proceed to examine the Volutoid population of different upper Cretaceous districts, where the invertebrate fauna has been well worked out or is sufficiently known.

The chief districts are situated in India; in the Gosau district of the eastern Alps, and the Aachener chalk of northern Germany; the Greensand marls of New Jersey, the Ripley group of the Gulf States, the *Pugnellus* sandstone at the top of the Benton group in Colorado, and the Chico group of California. These range from the middle (Turonian) to the uppermost Cretaceous.

Dr. Stanton, while disclaiming the practicability of exact correlation between the subdivisions of the Cretaceous in the United States and those of foreign countries, is disposed to regard the Colorado, Trichinopoly, Chico, and Gosau horizons as in part representing the Turonian, while Ripley and Aachen correspond to some portion of the Senonian.

In India the fauna of the series known as the Trichinopoly group has been discussed by Sowerby, Forbes, and Stoliczka. The latter author had an unfortunate tendency toward uniting under one specific name very different things, if only they possessed a superficial resemblance—a course more fatal to scientific accuracy than going to the opposite extreme. However, he worked with great industry and erudition and gave good figures of the fossils, so that paleontologists are under serious obligations to him for his work in India. His early review of the Gosau fauna was hasty and insufficient; it is replete with erroneous conclusions. Zekeli, whom he criticized severely, is—if any confidence is to be placed in the illustrations of his monograph—a far more discriminating author than his critic. Naturally, in the discussion of these exotic faunas one must assume that the illustrations of a reputable author are at least approximately accurate in depicting the species figured.

The Volutidæ of the Trichinopoly group, with one or two exceptions, have a somewhat similar sculpture while varying widely in form. The slender, widely separated spiral ridges are more pronounced than the axial sculpture, in proportion to their size the shells are only moderately thick, the posterior sinus of the aperture is well marked in the adults, and the columellar plaits are small, slender, not crowded, and three or more in number. The characteristics of *Volutoderma,* which is the most typical of these volutes, include a posterior sinus for the protrusion of a part of the mantle, which in the enameled species (*Volutomorpha*) serves to distribute the glaze.[1] Judging by recent species, many of which have a similar sinus, the mantle edge as a whole is not extended over the shell except in the genus *Zidona.* Those authors who have referred members of this group to the Pleurotomidæ have therefore insufficient basis for that opinion.

Beside the sinus, the small smooth shelly protoconch, the appressed suture, the whorl often excavated above the shoulder, the reticulate sculpture, and the three plaits on the pillar often lagging behind the aperture, are characteristic of most of the species where ever found. In many cases the edge of the outer lip where the spiral ridges terminate is provided with a small denticle corresponding to each ridge, and it is not uncommon to find a ridge of enamel in the wake of the posterior sinus, which forms a sort of fasciole.

Among the types represented are the *piruliform,* in which the spire is almost involved within the outer whorls and elevated very little above them, while the whorls are rounded and inflated behind. This has been named *Ficulopsis* by Stoliczka. Its analogue in the Aachen chalk is *Ficulomorpha* Holzapfel; in the Martinez of California, *Retipirula* Dall[2]; in the Eocene of Gatun, Panama, this type has a successor in *Glyptostyla* Dall. In these forms there are two to five plaits.

Another type has also a low spire, but with the shoulder keeled or angular, the whorl behind it flattish and the sides of the whorl in front of the keel flattened as in the genus *Conus.* This is named by Stoliczka *Gosavia,* and has representative species in the Gosau and Aachen formations and probably one in New Jersey. According to Stoliczka and d'Archiac, there is an Eocene species *G. dentata* (Sowerby) in the Nummulitic of India, which Noetling also reports from the Miocene of Burma.

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[1] This sinus differs in function from that of the Pleurotomidæ. In the latter group it allows the protrusion of an elongated tube which carries the fecal matter outside the cavity of the mantle (as in *Pleurotomaria*) and thus prevents fouling the water which has access to the gills. In the Volutidæ the anus is anterior and its products are ejected more or less laterally, as in the majority of Prosobranchs.

[2] *Turbinella crassitesta* Gabb, Pal. Cal., II, pl. XXVI, fig. 37, 1869, is the type.

The prevalent type belongs to a section of *Volutoderma* having a peculiar facies already alluded to, and which we propose to call *Rostellinda*. Of these there are five species confounded by Stoliczka under one name which belongs to none of them. They are mostly large shells with axial ribs and shouldered whorls, the whorl excavated in front of the suture, the sinus near the suture, the axial sculpture feeble, the spiral sculpture stronger on the spire or weaker or obsolete on the last whorl. The species are *Volutoderma* (*Rostellinda*) *stoliczkana* Dall[1] (type); *V.* (*R.*) *excavata* Dall[2]; *V.* (*R.*) *tenua* Dall[3]; *V.* (*R.*) *media* Dall[4]; *V.* (*R.*) *teinostoma* Dall[5] and perhaps *V.* (*R. ?*) *trichinopolitensis* Forbes[6]; and *V.* (*R.*) *multistriata* Stoliczka.[7] Besides these, there is a species resembling *Caricella* Conrad, but which according to Stoliczka has a globular nucleus and a complete layer of enamel over the whole shell. It was described as *Voluta pyriformis* by Forbes and will form the type of a new genus *Liomelon* Dall.[8] There are one or two other species which probably belong to *Volutoderma,* but which, owing to their imperfect state, it is more prudent to leave undiscussed.

In addition to the species belonging to the group under discussion, there are a number of forms belonging to the Volutidæ of the Indian Cretaceous which, by the peculiarity of their columellar folds and general type of form, are evidently the forerunners of the genus *Plejona,* which only attains its fully characteristic development in the Eocene, and of *Volutocorbis,* which has persisted through subsequent ages and is represented in the recent fauna by several species. The anatomical examination of one of these has shown that *Volutocorbis* is a well characterized genus perfectly distinct from *Plejona* or *Volutilithes,* and, in the adult, with a thickened and internally dentate outer lip.

The analogous fauna of the Gosau district among the northeastern Alps was treated by Sowerby and Stoliczka, and monographed by Zekeli. The synonymy of the species has been vastly confused by

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[1] Cret. Gastr. India, Stoliczka, pl. VII, figs. 7 (type) and 6. The names here given by the present writer are new.

[2] *Opus cit.,* pl. VII, fig. 5.

[3] *Opus cit.,* pl. VII, fig. 3.

[4] *Opus cit.,* pl. VII, figs. 9 (type), 4, and 8.

[5] *Opus cit.,* pl. VII, figs. 2, 2*a* (type), and fig. 1.

[6] *Opus cit.,* pl. VI, fig. 6, *Scapha gravida* Stoliczka.

The figures agree so perfectly that I cannot doubt their identity. The form referred to Forbes' species by Stoliczka, at any rate, cannot be identical with it.

[7] *Opus cit.,* pl. VIII, figs. 1, 2, 3, very imperfect.

[8] *Opus cit.,* pl. VI, figs. 9, 9*a*, *Melo pyriformis* Stol.

indiscriminate "lumping" of species. The fauna comprises, as well as can be determined from the fine illustrations given by Zekeli, without an opportunity of also consulting the fossils, two species of *Gosavia, G. gradata* Zekeli, and *G. squamosa* Zekeli, the latter a very coniform species and the type of the genus. There are typical species of *Volutoderma; V. perlonga* Zekeli (*prælonga* in the legend to the plate); *V. fenestrata* Müller (*non* Zekeli), and the less characteristic species *V. Mülleri* Dall[1] (=*fenestrata* Zekeli *non* Müller) and *V.* (*Rostellaca*) *subsemiplicata* Orbigny. The group of short species having a somewhat nassoid aspect, usually with rather numerous axial ribs and feeble spiral sculpture, which I propose to separate sectionally under the name of *Rostellana* with *V. Bronni* Zekeli[2] as type, comprises also *V. gasparini* Orbigny (*acuta* Zekeli *non* Sowerby), *V. acuta* Sowerby (*non* Zekeli), *V. coxifera* and *V. cristata* Zekeli. This group is also represented in the Pugnellus sandstone of Huerfano Park, Colorado, by allied species.

In the analogous group of forms from Aachen admirably illustrated by Holzapfel in the Paleontographica, we find a different and much rougher type of sculpture, with nodulation of the intersections, the axial and spiral ridges more nearly equal in strength, the shells smaller, the shoulder less emphasized and the posterior sinus less conspicuous. In the coexisting genus *Ficulomorpha* we find an absence of axial sculpture, the nucleus is subglobular, the shoulder evanescent, the spire largely involute, giving a pyriform aspect to the shell, which has a wide recurved canal in the adult. The aspect strongly suggests *Ficula* if it were not for the heavy shell and plaited pillar. This external resemblance has led several authors to regard the species as a plaited precursor of *Ficula*. But the young shell has a relatively higher spire and straighter canal with the oblique plaits and globular nucleus of the *Volutidæ*, and is not more pyriform than *Callipara*, which no one doubts belongs to the Volutidæ. In fact, the difference in form is almost entirely, in this case, due to the gradual involution of the spire with age, and the resemblance to *Ficula* is purely superficial. This genus retains the posterior sinus characteristic of nearly all Mesozoic and many subsequent Volutidæ.

A very close ally, probably only sectionally distinct from *Ficulomorpha*, is *Glyptostyla* Dall, described from the Gatun Eocene on the line of the Panama canal. It differs from the Aachen fossil by

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[1] Zekeli, Gosaugebilde, taf. XII, fig. 6. New name.
[2] Zekeli, *Op. cit.*, taf. XII, fig. 9.

its reticulate instead of spiral sculpture, its better differentiated canal, and in having two instead of three columellar plaits. The type, *F.* (*G.*) *panamensis* Dall, is figured in the Transactions of the Wagner Institute of Science, volume III, plate XIII, figure 5, 1892.

The *Volutoderma* of the Aachen chalk are characterized, as above noted, by a quite different type of sculpture from those of India or even of Gosau, not to speak of the United States. They vary considerably in form, as do the analogous groups in other regions, but have a distinctly common facies. For these I propose the sectional name *Rostellaca,* with *R. zitteliana* Holzapfel as type.[1]

The fauna also contains the following other species which I refer to the same section: *V.* (*R.*) *subsemiplicata* Orbigny; *V.* (*R.*) *fenestrata* Roemer; *V.* (*R.*) *gosseleti* Holzapfel and *V.* (*R.*) *holzapfeli* Dall,[2] the last being obviously distinct from *V. fenestrata* Roemer, with which it is united in Holzapfel's monograph.

Passing over for the moment the Greensand marls of New Jersey, we may consider next the group of species described by Stanton[3] from the Pugnellus sandstone of Huerfano Park, Colorado, which form probably the oldest assembly of this family yet described from the United States.

In this group the number of species known is not large, and none of them are typical *Volutoderma.* The list comprises *Volutoderma* (*Rostellinda*) *dalli* Stanton and a varietal or possibly specific form *plicatula* Dall[4]; *V. ambigua* Stanton; *V.* (*Rostellana ?*) *gracilis* Stanton; and *V.* (*Rostellana ?*) *constricta* Dall,[5] the latter two being nearly intermediate smooth types.

The Greensand marls of New Jersey contain a large Volutoid fauna, which, unfortunately, is preserved only in the form of internal casts. This forbids very satisfactory identifications specifically. Still the impressions distinctly convey the idea that a number of the shells belonged to the genus *Volutoderma* in the strict sense, while the others, as usual, assume a variable aspect. Altogether there are five or six species of *Volutoderma* in the lower marls and four species of *Volutomorpha* Gabb. The latter genus differs from *Volutoderma* by its sculpture, by having a single strong plait on the columella, and especially by the fact that the outer surface in the adult is covered with a varnish-like enamel. The principal character

[1] Holzapfel, Paleontographica, Bd. XXXIV, taf. VIII, fig. 4*a*–*b*.
[2] Holzapfel, *op. cit.,* taf. VIII, fig. 6.
[3] Bull. No. 106, U. S. Geological Survey, 1893, pp. 155–158, pls. XXIII, XXIV.
[4] Stanton, *op. cit.,* pl. XXXIII, fig. 10. New name.
[5] Stanton, *op. cit.,* pl. XXXIV, fig. 3. New name.

in Gabb's eyes was the possession of the single strong plait; and his type, an internal cast, upon which the name of *V. conradi* was bestowed, exhibited plainly only this character. The others are taken from other species, but which are probably correctly referred to this genus. The middle marl contains two or three species of *Volutoderma;* the upper marls three, of which one probably may be referred to the subgenus *Gosavia.*

The upper Cretaceous (Ripley) beds of the Gulf states were more fortunate in the state of preservation of their fossils. In Texas was obtained *Volutoderma texana* Conrad, upon which Conrad founded his genus *Rostellites,* a name preoccupied by Fischer since 1806. The later *Volutoderma* Gabb, is based upon a Californian species. There are three species of this genus in the Ripley formation, one of which is new, and of *Volutomorpha,* beside the *V. eufaulensis* Conrad, there are five very remarkable species yet unpublished. All these are large, brilliantly polished shells.

Some time since[1] I described a recent shell under the name of *Volutilithes philippiana* from off the southwest coast of Chile, in 677 fathoms. It has very much such sculpture as the northern one we have been considering. The nucleus was eroded, but evidently had not been swollen or conspicuously large. A series of other forms, including some half dozen species, occur in the Santa Cruz Tertiary beds of Chile and Patagonia, which from the similarities of decoration seemed at that time likely to belong to the same group as the abyssal recent shell. This was supposed to belong with the Volutoid series having a shelly nucleus, and was so referred by me in a later publication.[2] All were tentatively referred to the Volutoid series and associated with Conrad's *Rostellites;* but more recent explorations in Patagonia have furnished perfect nuclei of several of these fossils, which have been figured by Ortmann,[3] who shows them to belong to the Caricelloid series (formerly called Scaphelloid), which have membranous and dehiscent protoconchs. It is altogether probable that the recent *V. philippiana* Dall is related to the regional fossil forms, and had, before erosion, a Caricelloid tip, in which case it would belong to *Adelomelon* as finally revised. The question now arises whether the northern *Miopleiona* is of the same stock, which, if so determined, would place it in a different subfamily from the *Volutoderma,* which is known to have a small shelly protoconch.

[1] Proc. U. S. Nat. Mus., XII, p. 313, pl. IX, fig. 4, 1889.

[2] Trans. Wagner Inst. III, p. 69, 1890.

[3] Ortmann, Princeton Univ. Exp. Patagonia, IV, p. 234, 1902. *cf.* pl. XXXV, fig. 4*d,* and pl. XXXVI, fig. 1*c.*

Until specimens preserving the nuclear whorls are obtained the decision must rest in abeyance.

We now come to the Cretaceous of the Pacific slope, where, in the Chico series, we have the typical species of *Volutoderma*, *V. californica* Dall[1]; a larger and more robust species, figured and described by Dr. C. A. White[2] under the name of *Fulguraria gabbi*, and *V.* (*Rostellinda*) *dilleri* White.[3] A fourth species occurs in the Cretaceous of Sucia Island, British Columbia, which I have named *Volutoderma suciana*.[4]

This species is most nearly related to *V. gabbi* White, and not to *V. texana* (+ *navarroënsis*); it differs from *V. gabbi* in its more slenderly fusiform shape, its higher and more acute spire, more delicate spiral ridges, the more anterior periphery to the last whorl, and in the absence of marked axial ribbing.

I am indebted to Dr. J. F. Whiteaves, of the Dominion Geological Survey, for the opportunity to examine the original specimens from Sucia Island. It may be added that the figure above cited gives an insufficient idea of the strength and disposition of the spiral sculpture, the specimen from which it was made having evidently been more or less decorticated.

In the lowest Eocene of the Martinez horizon in California was collected *Retipirula crassitesta* Gabb, before alluded to, but, with the exception of *Ficulomorpha* (*Glyptostyla*) *panamensis* Dall, from the far south, no relatives of the genus *Volutoderma* have yet been made known from the Californian or Oregonian Eocene. *Retipirula* differs from *Ficulopsis* by having a sculpture reticulate with rather wide intervals and strong nodulation at the intersections. It also resembles

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[1] Gabb, Pal. Cal. I, p. 102, pl. XIX, fig. 56, (1864). New name for *V. navarroënsis* Gabb, not Shumard.

[2] Bull. U. S. Geological Survey, No. 51, pl. III, fig. I, 1889.

[3] Bull. U. S. Geological Survey, No. 51 (as *Scobinella dilleri*), pl. IV, figs. 1, 2, 3.

[4] Whiteaves, in Mesozoic Fossils, Geol. Survey of Canada, vol. I, part II, 1879, p. 117, pl. XV, figs. 3, 3*a*, under the name of *Fulguraria navarroënsis* Shumard, the true *navarroënsis* being identified with *Volutoderma texana* Conrad, a sufficiently distinct species.

The following notes will indicate the distinctions:

V. suciana has seven whorls; three strong plaits, of which the anterior is weakest; an appressed suture; an evident posterior sinus; and sculpture consisting of four simple spirals in front of the suture; then two nodulous spirals, a peripheral nodulous spiral with wider interspaces on each side of it; then eleven more or less nodulous spirals, followed by two faint simple ones on the canal. The axial ribbing found in several other species is obsolete or absent. Length 120; spire behind the posterior sinus 44; max. diam. 45 mm.

Glyptostyla and *Miopleiona* in having two strong plaits, rather than four or five feeble ones, as in *Ficulopsis* and its associates, *Gosavia* and *Rostellinda*. In each case the presumption is that the species is an offshoot from a local group with more elevated spire and not genetically connected with its exotic analogue.

In the Oligocene concretions from the Astoria, Oregon, beds below the Miocene, the United States exploring expedition under Wilkes in 1841 collected a specimen of a species belonging to a genus related to *Volutoderma* which was later described by Conrad under the name of *Rostellaria indurata*. It was associated with *Aturia* and other Oligocene types. The original specimen is an internal cast retaining only small fragments of the shell. With more material, it appears that the species is common to the Oligocene of Washington, and is represented in the Miocene and Pliocene of Oregon and California by a related but distinct species. For these the name *Miopleiona* is proposed, and it is not absolutely impossible that deep-sea dredgings off the coast may reveal in the future a recent representative.

The Eocene connecting link between the Cretaceous *Volutoderma* and the Oligocene representative, on the Pacific coast, is not yet known; but recent investigation by Dr. Ralph Arnold, of the U. S. Geological Survey, under the writer's direction, have fortunately discovered specimens of Conrad's *V. indurata* which retain portions of the outer surface. From these we learn that this species was characterized by slender, elongated form, long strap-like axial ribs, with slightly wider interspaces, which reach nearly to the base of the whorls (in a specimen 70 mm. long), while the whole surface is sculptured by fine, close, threadlike, spiral striations. The plaits are of the type of *Volutomorpha* and not like those of *Volutoderma*, and the sutural constriction is obsolete. The genus continues into the Miocene, where it appears in a species in which the presutural constriction (but not the posterior sinus) has vanished, though the suture is still slightly appressed; the spire is shorter and blunter and the whole form less attenuated. The axial sculpture is still of slender, elongated ribs, but there is no spiral sculpture. The columellar plaits are unchanged. This will take the name of *M. oregonensis*.

Having described the origin and distribution of this interesting group of Volutacea, we may close the discussion with a tabular exhibit of the groups arranged to show the recurrence of specialized types of form in successive horizons, and with descriptions of the new Cretaceous species previously alluded to.

In the following table, after the Cretaceous, no attempt has been made to include groups not represented in America (unless *Athleta* be so regarded), nor is the arrangement intended to be systematic. It is intended rather to illustrate the feature referred to earlier in this paper, viz., the recurrence of similar types of form in successive ages or horizons; or, in widely separated regions in the same age, without regard to close genetic connection. The subordinate sections of *Volutoderma* are omitted here, but will be found elsewhere.

The year indicates the date of publication of the name following, to which is added the general region and the name of the typical species. When a group-name recurs in the table the type species is mentioned only in connection with the earliest appearance of the group, which, however, may have a type species belonging to a later horizon.

The names preceded by an asterisk belong to the Caricellinæ, those without the asterisk to the Volutinæ. All are grouped with reference to external forms.

PARTIAL LIST OF FOSSIL VOLUTIDÆ

Cretaceous

Piruliform

1868. *Ficulopsis* Stoliczka, India. *F. pondicherriensis* Forbes.
1888. *Ficulomorpha* Holzapfel, Aachen. *F. pyruliformis* Müller.

Coniform

1865. *Gosavia* Stoliczka, Gosau. *G. squamosa* Zekeli.

Muriciform

1906. *Plejona* (Bolten) Dall, worldwide. *P. spinosa* Lam.

Fusiform

1876. *Volutoderma* Gabb, worldwide. *V. californica* Dall.
1876. *Volutomorpha* Gabb, American. *V. conradi* Gabb.
1864. *Piestochilus* Meek, worldwide. *P. scarboroughi* Meek & Hayden.

Bucciniform

1890. *Volutocorbis* Dall, worldwide. *V. limopsis* Conrad.

Meloniform

1907. *Liomelon* Dall, India. *L. pyriformis* Forbes.

Eocene

Piruliform

1907. *Retipirula* Dall, California. *R. crassitesta* Gabb.
1892. *Glyptostyla* Dall, Panama. *G. panamensis* Dall.

Muriciform

1831. **Volutilithes* Swainson, worldwide. *V. muricina* Lamarck.
1906. *Plejona* (Bolten) Dall.

Bucciniform

1890. *Volutocorbis* Dall.

Fusiform

1835. **Caricella* Conrad, America. *C. prætenuis* Conrad.
1890. **Volutopupa* Dall, Europe. *V. cithara* Lamarck.
1906. **Maculopeplum* Dall, America. *M. Junonia* Hwass.
1890. *Liopeplum* Dall, America. *L. lioderma* Conrad.

Mitriform

1855. **Lapparia* Conrad, America. *L. dumosa* Conrad.

Strombiform

1847. *Lyria* Gray, America and Europe. *L. nucleus* Lam.

OLIGOCENE

Fusiform

1835. **Caricella* Conrad.
1907. *Miopleiona* Dall, West America. *M. indurata* Conr.

Strombiform

1847. *Lyria* Gray.

Meloniform

1890. **Eucymba* Dall. Florida. *E. ocalana* Dall.

MIOCENE

Fusiform

1853. **Aurinia* H. and A. Adams, America. *A. dubia* Brod.
1906. **Maculopeplum* Dall.
1906. **Adelomelon* Dall, America. *A. ancilla* Solander.
1907. **Miomelon* Dall, S. America. *M. philippiana* Dall.

Strombiform

1758. *Voluta* Linné, Atlantic shores. *V. musica* Linné.
1847. *Lyria* Gray.
1853. *Enaeta* Adams, America. *E. barnesii* Gray.

Cassidiform

1853. *Athleta* Conrad, Europe. *A. rarispina* Lamarck.

PLIOCENE

(Same series as the Miocene except *Athleta*.)

PLEISTOCENE

(Same series as the Pliocene with the addition of:)

1853. *Volutomitra* Gray, Boreal. *V. grönlandica* Beck.

We may now consider the undescribed or unfigured species in hand.

GENUS VOLUTOMORPHA GABB

VOLUTOMORPHA EUFAULENSIS Conrad

(FIGURE 1)

Volutilithes eufaulensis CONRAD, Journ. Acad. Nat. Sci., Phila., 2nd ser., IV, p. 286, pl. 47, fig. 18, Feb., 1860.

Volutomorpha cretacea (Conrad) GABB, Proc. Acad. Nat. Sci., Phila., 1876, p. 290 (=*eufaulensis* Conrad, *op. cit.*).

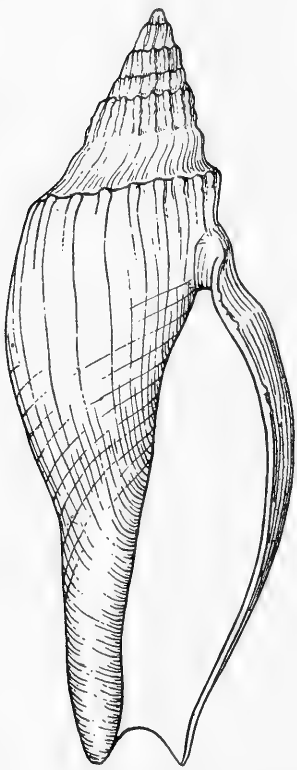

FIG. 1.—*V. eufaulensis* Conrad. ¾. Ripley, Miss.

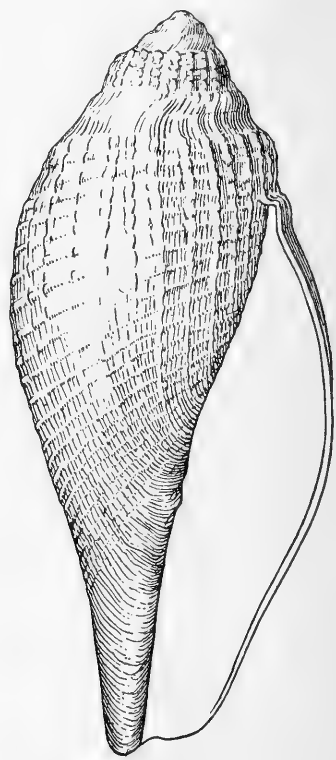

FIG. 2.—*V. retifera* Dall. ¾. Kaufman, Texas.

Shell with one moderately elevated plait in the penultimate whorl, obsolete at the aperture; fourteen to sixteen straight axial ribs, extending from shoulder to suture, with wider interspaces; behind the suture each rib has three obscure nodulations; suture appressed and swollen by a deposit of callus in the wake of the posterior sinus of the aperture; sinus situated at the suture, in the adult wide and deep; whorl in front of the suture constricted, carrying strong lines of growth and obsolete distant spiral cords, which also exist over the body; where each cord terminates at the outer lip appears a small projecting denticle; outer lip in the adult somewhat expanded; the whole shell at maturity covered by a coating of enamel which still further obscures the sculpture and sutures; whorls about five, the nucleus shelly, defective. Lon. of shell, 162; of aperture, 110; diam., 58 mm.[1]

Ripley formation of upper Cretaceous at Ripley, Miss.; the same horizon at Eufaula, Alabama; Bullock's Mill, near Dumas, Miss. (20,576); and near Mt. Olivet Church, Union county, Miss. (20,534); U. S. Nat. Mus. and Acad. Nat. Sci., Philadelphia.

The plait on the pillar in the fully adult shell becomes obsolete in the vicinity of the aperture and is invisible from in front. In the earlier whorls it is strong, lying in front of a shallow channel on the pillar; the posterior border of this channel, in the early stages of the shell, forms a second fairly well-marked plait. The substance of the shell as preserved is chalky white with a yellow-brown coating of enamel.

VOLUTOMORPHA RETIFERA Dall, n. sp.

(FIGURES 2, 3)

Shell with one evident plait in the adult, two in the early stages, lagging behind the aperture and hardly visible from in front; penultimate whorl with eighteen to twenty-one rounded ribs, most prominent at the shoulder, obsolete on the last half of the last whorl, but earlier extending well toward the base, with subequal interspaces; posterior sinus of the aperture deep, narrow, in the adult recurved (see figure 3), leaving a prominent ridge of callus in front of and close to the suture, in front of which the whorl is excavated, markedly so in the earlier whorls, and spirally obsoletely striated; the rest of the surface with about twenty-two spiral, strap-like ridges, very

[1] Conrad's original figure, though characteristic, was taken from a crushed specimen which is abnormally wide.

evenly disposed, prominent but hardly nodulous at the intersections, forming with the ribs a coarse, rather regular reticulum; spire short, conic; suture appressed; the whole shell in the fully adult stage with a very thin coat of enamel; outer lip thin, expanded, slightly reflected; more or less denticulate at the extreme margin. Lon. of shell, 143; of aperture, 103; max. diam., 44 mm.

Ripley horizon of Upper Cretaceous at Kaufman, Texas (U. S. N. M., 20,996); collected by Dr. T. W. Stanton, U. S. Geological Survey.

This has somewhat the aspect of *V. eufaulensis,* but the spire is shorter and more blunt, the maximum diameter is more posterior, the sculpture is much more distinct and regular, the brilliant polish is wanting, and the substance of the shell has a peculiar brownish tint and subtranslucent character, which is probably not entirely due to conditions of fossilization.

VOLUTOMORPHA DUMASENSIS Dall, n. sp.

(FIGURE 4)

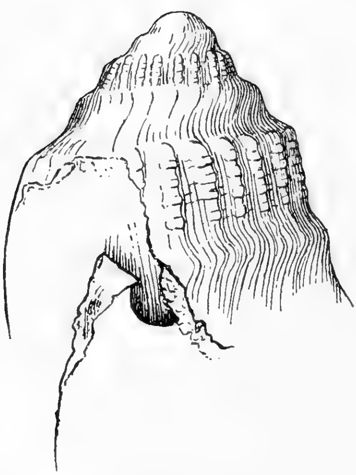

FIG. 3.—*V. retifera* Dall. *1/1.* Side view of fragment, showing mold of recurved posterior sinus.

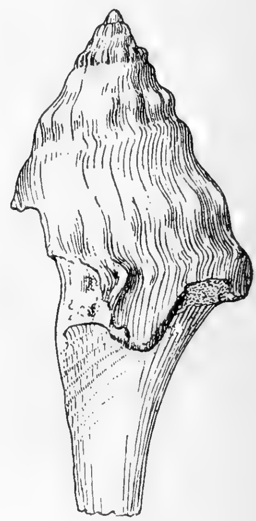

FIG. 4.—*V. dumasensis* Dall. 1/1. Fragment, showing character of spire and shallow posterior sinus.

Specimens all imperfect, but showing one strong and one obsolescent plait; penultimate whorl with thirteen short riblike swellings at the periphery, weaker in front and absent behind, where there is a wide shallow constriction of the whorl extending from the periphery to the swollen fasciole by the posterior sinus, the whole with faint sparse spiral threads with slightly wider interspaces; posterior sinus strong, short, not deep; whole shell with a thick coat of enamel, and about six whorls, anterior portion defective in all the specimens. Lon. of spire above the posterior sinus 48, diameter about 45 mm.

Ripley formation of Upper Cretaceous at Bullock's Mill, near Dumas, and Mount Olivet Church, Union county, Miss. (20,503 and 20,576 in part, U. S. Nat. Mus.).

Although imperfect, the form and sculpture indicate a distinct species easily recognizable from the differential characters of the diagnosis. The substance of the shell is soft and chalky.

VOLUTOMORPHA ASPERA Dall, n. sp.

(FIGURE 5)

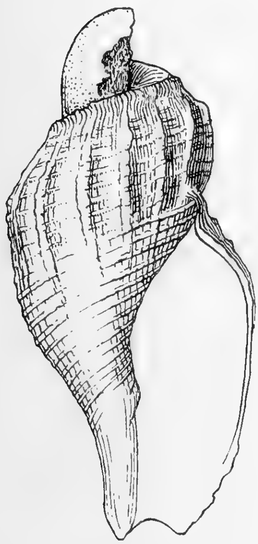

FIG. 5.—*V. aspera* Dall. 1/1. Ripley, Miss.

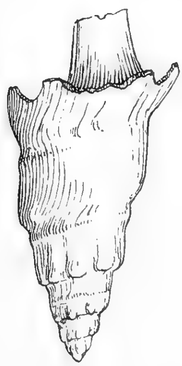

FIG. 6.—*V. turricula* Dall. 1/1. Upper part of spire, showing sculpture and form. Bullock's Mill, near Dumas, Miss.

Shell considerably crushed and wanting the earlier whorls, but showing one well-marked plait; the last whorl with about thirteen narrow ribs, obsolete in front of the suture, prominent at the shoulder, weaker over the body; the whorl between suture and shoulder constricted and more or less axially wrinkled; posterior sinus at the appressed suture; the sinus is narrow and shallow; spiral sculpture of rather close-set cords with narrower interspaces; there are about twenty-six spirals in front of the shoulder on the last whorl; surface with a thin wash of enamel and an obscure callous ridge in front of the suture; outer lip thin, slightly expanded, strongly denticulate at the edge in front; spire elevated, but defective in the type. Lon. of last whorl 62, of aperture 47, max. diam. 32 mm.

Ripley formation of the Upper Cretaceous, at Ripley, Miss. U. S. Nat. Mus., 20,404.

The rough surface sculpture and strong spiral threading sufficiently distinguish this species from any of the others.

VOLUTOMORPHA TURRICULA Dall, n. sp.

(Figures 6 and 7)

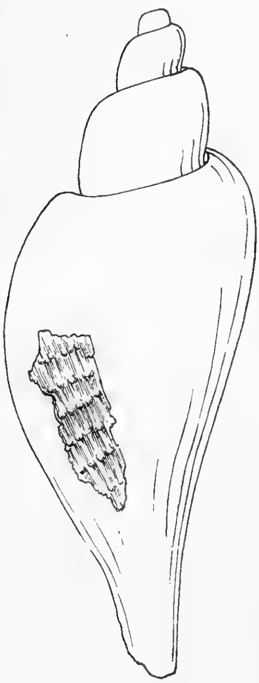

Fig. 7.—*V. turricula* Dall. ½. Showing general proportions of the shell and a small patch of the external sculpture. Bullock's Mill, near Dumas, Miss.

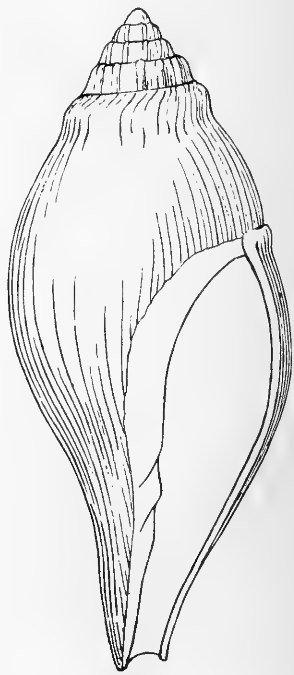

Fig. 8.—*V. lioica* Dall. ¾. Nearly adult shell. Ripley formation at Eufaula, Ala.

Shell with the plaits as in *V. eufaulensis;* whorls about six and a half, the whole shell thickly enameled; spire elevated, slender, not swollen at the suture, in front of which there is a moderate constriction, behind which there is a single spiral cord, obsolescent on the later whorls; the apical whorls have nine peripheral nodules at the shoulder; nucleus shelly, minute; posterior sinus shallow, situated at the suture (see figure 6); anterior portion wanting. Lon. of spire in fragment 38, diam. 20 mm. U. S. Nat. Mus., 20,573.

A decorticated and much larger specimen from the same locality appears to belong to the same species; if so, the last whorl develops near the anterior part of the outer lip distant and oblique spiral threads (which appear on a patch of surface remaining), which break up into low rounded pustules and seem not to have extended far from the margin, but probably correspond to the denticulations of the outer lip in the adult. This specimen, with an allowance of 14 mm. for its missing apex, measured: Lon. of shell 195, of aperture 131; diam. at post. sinus about 48; max. diam. of last whorl about 62 mm. (U. S. Nat. Mus., 20,576, part.)

Upper Cretaceous of Bullock's Mill, near Dumas, Miss. U. S. Geological Survey.

This large species is well distinguished by its slender elongate spire, its sculpture and the small number of its riblets. I am quite confident, though not absolutely certain, that the large decorticated specimen represents the adult of what I regard as the type specimen (fig. 6); in which case it is probably the largest species of the genus, of which the shell is known. Both specimens were collected at the same time and in the same locality.

VOLUTOMORPHA LIOICA Dall, n. sp.

(FIGURE 8)

Shell large, solid, with one strong plait between two shallow excavations, probably with two well-marked plaits in the early stages; spire short, conic, with about fourteen obsolete axial riblets on the antepenultimate and earlier whorls; sutural callus prominent, the whorl in front of it slightly or not at all constricted; body of shell smooth, anterior third with sparse obsolete sulci, becoming closer on the canal; posterior sinus deep, narrow, outer lip hardly reflected, but with a few small pustular prominences on its outer edge; the whole shell enameled. Lon. 117, max. diam. 47 mm.

Collected by the U. S. Geological Survey from the Ripley formation of the Upper Cretaceous at Eufaula, Alabama. U. S. Nat. Mus., 21,127.

This species, by its smooth surface, is strongly contrasted with the others and is easily discriminated. The substance of the shell is soft and chalky, the enamel yellowish. Two precisely similar and rather well preserved specimens were obtained.

GENUS VOLUTODERMA GABB

VOLUTODERMA TEXANA Conrad

(FIGURE 9)

Rostellites texano CONRAD, in Emory's Report on the Mexican Boundary, p. 158, pl. XIV, fig. 2, 1855.

Volutilithes navarroënsis SHUMARD, Proc. Bost. Soc. Nat. History, VIII, p. 192, 1861.

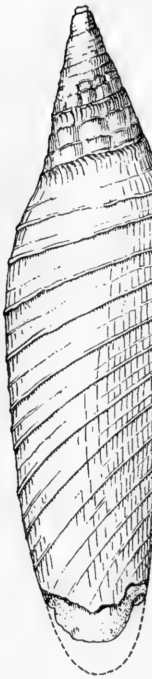

FIG. 9 — *V. texana* Conrad, dorsal view showing form and exterior sculpture. ⅔.

By platting the dimensions and filling in the details given in Shumard's very full description, it is easy to make a diagrammatic figure which is recognizable. Conrad's species was figured from an internal cast, preserving only a narrow strip of the outer surface near the pillar. The spiral cords were taken to be columellar plaits, which gave a wholly erroneous idea of this portion of the fossil. Only three plaits are present. Conrad's type is preserved in the U. S. Nat. Museum (No. 9886). There is no reasonable doubt that his species is identical with that of Dr. Shumard, having been collected from the same horizon and region and agreeing essentially. Since Shumard's species was never figured and the figure given by Conrad represents only the internal cast, it seemed advisable to figure the better-preserved form which later researches have brought to light and which retains the substance of the shell. Figure 9 represents such a specimen, No. 20,992 U. S. Nat. Museum, from Kaufman, Texas. The following data, additional to those given by Conrad, are deducible from the material brought together by Dr. Stanton from various places in Texas, especially near Webberville, Texas, No. 21,183.

Pillar with three feeble plaits, becoming obsolete near the aperture, the "numerous plaits" of Conrad being based on remnants of the external spiral cords, and not on the true plaits; early whorls with 8-10 rounded axial riblets, obsolete on the last whorl; suture appressed, the whorl in front of it flattish, with no well-marked shoulder, but more or less distinct axial wrinkling just in front of the suture; on the last whorl there are 15-17 prominent, distant, sharp spiral ridges, without nodulations; separated by much wider, slightly excavated, axially striate interspaces in which occasional much finer intercalary spirals sometimes appear; outer lip thin, in the adult anteriorly expanded, slightly reflected; the posterior sinus narrow, well marked, close to the suture. Lon. 124; of aperture, 87; max. diam. 33 mm.

VOLUTODERMA PROTRACTA Dall, n. sp.

(FIGURE 10)

Shell very elongate, thin, with 8 whorls; pillar straight, with three feeble plaits lagging behind the aperture; on the early whorls 7-8 rounded axial ribs, obsolete on the later whorls; whorls slightly constricted in front of the appressed suture; sutural margin with conspicuous imbricated scales and striation axially directed, crossed by 3-5 faint spiral threads; on the body of the last whorl are 19-20 sharp spiral ridges with much wider, somewhat excavated interspaces; the spiral ridges are sometimes gently undulated but not nodulous, and there are occasionally faint intercalary spiral threads; outer lip thin, slightly reflected; posterior sinus close to the edge of the suture. Lon. 155; of spire above the first whorl, about 40; max. diam. 36 mm.

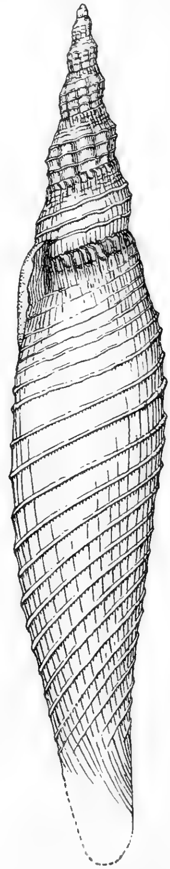
FIG. 10.—*V. protracta* Dall. ¾. Posterior sinus shown in profile.

Types are from the Ripley formation at Eufaula, Alabama, U. S. Nat. Mus., No. 21,129; other specimens are from the same horizon at Owl Creek bluff, Ripley, Miss. (20,430); and Kaufman, Texas (20,992).

The figure given of this remarkable species is diagrammatic, being a restoration from a number of fragmentary specimens. The shell is so thin that no specimen was collected showing an entire shell of adult stature. The specimen from Texas is partially an internal cast, and is defective both at the apex and the end of the canal, but still measures 142 mm. in length and about 32 mm. in maximum diameter. The shell in this specimen, which is more solid than those from the more eastern localities, has a maximum thickness in the last whorl of about 3 mm. The surface, as in all the species of this genus, is dull and rude, contrasting strongly with the brilliant polish of the species of *Volutomorpha* from the same horizon. The shell is proportionately more slender than any Volute, recent or fossil which is known to me.

TURBINELLIDÆ

GENUS PSILOCOCHLIS DALL

PSILOCOCHLIS McCALLIEI Dall

(FIGURES 11, 12, 13)

Turbinella (*Psilocochlis*) *McCalliei* DALL, Nautilus, XVIII, No. 1, pp. 9–10, May, 1904.

FIG. 11.—*Psilocochlis McCalliei* Dall. 4/5. Outer lip wanting; the enamel worn off a large part of the shell. Type specimen. Eocene of Georgia.

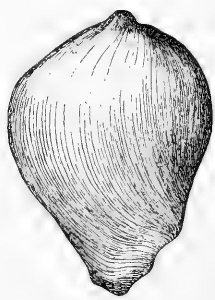

FIG. 13.—*Psilocochlis McCalliei* Dall. 4/5. Dorsal view of another specimen, showing complete investiture by a coat of enamel concealing the sutures.

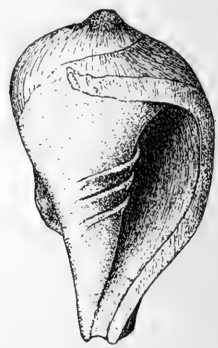

FIG. 12.—Same as figure 11, turned so as to show the plaits on the pillar. The projection on the left is the siphonal fasciole.

Shell of about four whorls, of which the earlier three are comparatively small, the apex hardly rising above the general dome of the spire, and still further concealed in the adult by a coating of enamel with which the entire shell is varnished, concealing the sutures; shell widest at about the posterior angle of the aperture, the last whorl diminishing forward and slightly constricted behind the strong and flaring siphonal fasciole; umbilical funnel smooth and almost filled by a smooth appressed mass of callus, continuous over the body and much thickened on the posterior part of the inner lip; surface without any sculpture except microscopic incremental and revolving lines; outer lip defective but apparently simple and sharp. Length (fig. 11) 50, max. breadth about 38 mm.

Collected from the Claibornian Eocene of Richmond county, Georgia, by Mr. S. W. McCallie, of the State Geological Survey, one-half mile north of Hephzibah, Georgia.

This was first described from a specimen (figs. 11, 12) in which the external coating of enamel had been largely removed by decay or wear. It was supposed to be a subgenus of *Turbinella,* but the discovery of other specimens, later, has led me to assign it full generic rank. One of these (fig. 13), though in some respects poorly preserved, showed that the adult shell is completely covered by a coat of enamel, something hitherto unknown among the *Turbinella* species, recent or fossil. This character, therefore, must be added to those given in the original subgeneric diagnosis, to render the generic description complete.

Though representing a collateral branch of the stem from which the Volutidæ are descended, this genus is sufficiently allied to find a place in this paper without incongruity; and this is the more desirable since no figure of the fossil has been published up to the present time.

The specimens figured form part of the collection of Tertiary fossils of the U. S. Nat. Museum, No. 110,379.

NOTES ON SOME SQUIRRELS OF THE SCIURUS HIPPURUS GROUP, WITH DESCRIPTIONS OF TWO NEW SPECIES

By MARCUS WARD LYON, Jr.
Assistant Curator, Division of Mammals, U. S. National Museum

Squirrels of the *Sciurus hippurus* group are represented in the collections of the U. S. National Museum by sixteen specimens, over half of them collected by Dr. W. L. Abbott in his explorations of Malaya, among them two forms not previously described. Squirrels of this group have been recorded from the Malay Peninsula, Sumatra, Java, Borneo, and the Natuna Islands.[1] They have not been taken by Dr. Abbott or by other collectors, so far as I am aware, on the numerous smaller islands of the Malay Archipelago. Whether this is due to an actual absence of the group from those islands, or to rarity, or to some peculiarity of habit, it is impossible to say.

Four forms of this group are here recognized, two of which occur on the Island of Borneo. They may be known by the following key and descriptions:

A.—Middle line of back very different in color from rest of upperparts. *S. grayi* (Borneo)

A'.—Middle line of back not different in color from rest of upperparts.

- *B.*—Size smaller, outer side of forearm concolor with upperparts. *S. hippurellus* (Borneo)
- *B'.*—Size slightly larger, outer side of forearm concolor with sides of neck.
  - *C.*—Rostrum narrow, dorsal portion of premaxillæ very narrow; underparts lighter .... *S. hippurosus* (Sumatra)
  - *C'.*—Rostrum not so narrow, dorsal portion of premaxillæ broad; underparts darker.. .. *S. hippurus* (Malay Peninsula, Java)

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[1] Anderson, Zool. Results, Western Yunan, 1879, p. 241 (Malay Peninsula, Sumatra, Java).

Bonhote, Fasc. Malay. Zool. I, 1903, p. 19 (Malay Peninsula).

Geoffroy, Mag. de Zool., Cl. I, No. 6, pl. 6, 1832 (Java).

Gray, Ann. Mag. Nat. Hist., 3d ser., xx, 1867, p. 283 (Malacca, Borneo).

Hose, Mammals of Borneo, 1893, p. 45 (Borneo).

Jentink, Notes Leyden Mus., v, 1883, p. 118 (Malay Peninsula, Sumatra, Borneo).

Schlegel and Müller, Verhandl. Nat. Gesch. Nederl. Overz. Bezitt., p. 86 (Sumatra, Assam, Canton, China).

Willink, Natuurkundig Tijdschrift Nederlandsch-Indië, LXV, 1905, p. 239 (Sumatra, Java, Borneo, Natunas).

SCIURUS HIPPURUS Is. Geoffroy

1832. *Sciurus hippurus* Is. GEOFFROY, Mag. de Zool., Cl. I, No. 6, pl. 6 (Java).
1842. *Sciurus rufogaster* GRAY, Ann. Mag. Nat. Hist., X, 1842, p. 263 (Malacca).

Cotypes.—In the Paris Museum of Natural History, two mounted specimens from Java, collected by Diard in 1826 and 1832.

Mr. Gerrit S. Miller, Jr., in some notes on types in the Paris Museum in 1904, remarks that three mounted specimens are marked "type." The third specimen came from Malacca, and was taken by M. Edoux in 1838 (Voyage de la *Bonite*). As this specimen was collected six years after the original description was published, it has evidently been erroneously marked "type." No reference is made to specimens elsewhere than from Java in the original description.

Color (based on specimens from the Malay Peninsula[1]).—Back and sides of body, top of neck from behind ears, and upper surface of base of tail, a grizzle of black and raw sienna, the latter color rather in excess and sometimes inclining to tawny on the lower back and base of tail. Top and sides of head and neck, region in front of shoulder, outer surface of forearm, sides of rump, and outer surface of thighs and legs, blackish slate, finely grizzled with white. Feet blackish slate, very slightly specked with a dull whitish color. Underparts and inner sides of fore and hind limbs hazel, slightly brighter than that of Ridgway.[2] Tail generally a dull black, sometimes inclining to brownish black, coarsely grizzled at the base above with the raw sienna of the upper parts, and at the base below slightly grizzled with whitish.

Skull.—The skull shows no special peculiarities. The portion of the premaxillæ appearing on the dorsal surface of skull is moderately enlarged.

Measurements.—Mr. Miller made the following measurements on the specimens in the Paris Museum: Java, male, head and body 280 mm., tail 220, hind part, with and without claws, 60, 57; Java, female(?), 290–235–65, 61; Malacca, female, 300–255–60, 57. For

[1] Mr. Miller noted that the three specimens in the Paris Museum showed no peculiarities, so that specimens from the Malay Peninsula are here regarded as typical *Sciurus hippurus*. It is very probable, however, that when good series of skins and skulls from Java are compared with specimens from the mainland that constant differences will be found between them, in which case Gray's name, *rufogaster*, is available for the peninsula form.

[2] Color terms in this paper are taken from Ridgway, Nomenclature of Colors for Naturalists, Boston, 1886.

measurements of the specimens in U. S. National Museum, see table, page 29.

Specimens examined.—Two from Trong, Lower Siam, and one from the east coast of Johore.

SCIURUS HIPPUROSUS, new species

Type.—Skin and skull of adult female, Cat. No. 141,031, U. S. N. M., collected at Tarussan Bay, west coast of Sumatra, December 18, 1904, by Dr. W. L. Abbott. Original number, 3826.

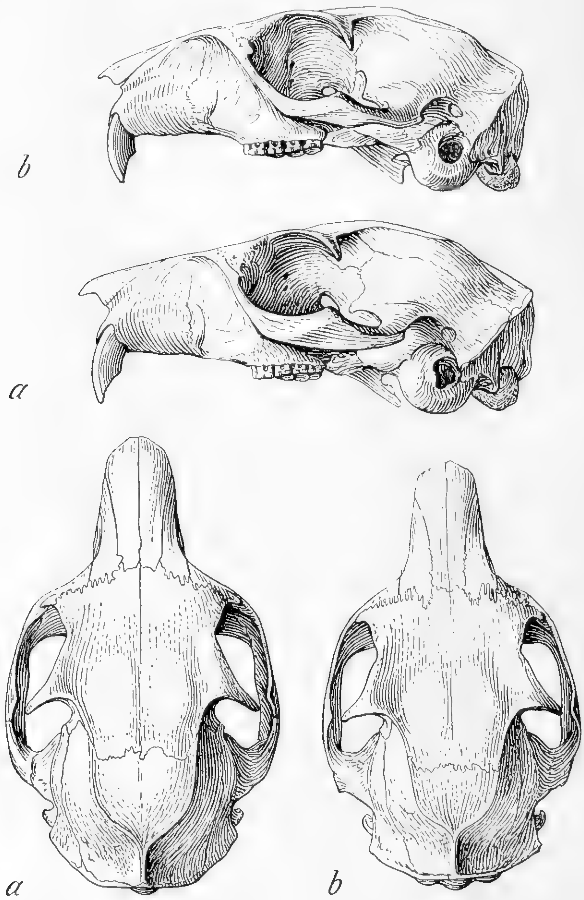


Fig. 12.—*a*, Cat. No. 141,031, Type of *Sciurus hippurosus*, Tarussan Bay, Sumatra; natural size.

b, Cat. No. 142,274, Type of *Sciurus hippurellus*, Landak River, western Borneo; natural size.

Diagnostic characters.—Similar to *Sciurus hippurus*, but larger, and with dorsal portion of the premaxillæ distinctly narrower.

Color.—*Sciurus hippurosus* so closely resembles *S. hippurus* that no detailed description is necessary. The underparts average perhaps a trifle lighter in color than they do in the mainland form, and a little more tawny is found in the upper parts.

Skull.—In addition to its average larger size, the skull of *Sciurus hippurosus* is distinguished from that of its allies by its relatively more slender rostrum, narrow dorsal surface of the premaxillæ, and heavier zygomata. (See figure 12, *a*.)

Measurements.—See table, page 29.

Specimens examined.—Three from Tarussan Bay, on the west coast of Sumatra, and one from Besitan River, on the east coast.

Remarks.—The three specimens from Tarussan Bay are uniform in all respects. That from the Besitan River has the underparts as dark as they are in the peninsula specimens, while above in the middle line the raw sienna color is replaced by rather bright tawny. The skull of this specimen is peculiar in lacking the small upper premolars and shows no place where they might have been. Should more material from eastern Sumatra show these differences to be constant, it would establish the existence of two forms of this squirrel in Sumatra.

SCIURUS HIPPURELLUS, new species

Type.—Adult female, skin and skull, Cat. No. 142,274, U. S. N. M., collected at Batu Ampar, on the Landak River, western Borneo, July 11, 1905, by Dr. W. L. Abbott. Original number, 4260.

Diagnostic characters.—Similar to *Sciurus hippurus*, but smaller and with dorsal surface of premaxillæ broad. (See fig. 12.)

Color.—*Sciurus hippurellus* so closely resembles *S. hippurus* in color that no detailed description is necessary, but it differs in the following particulars: The greater portion of the outside of the forearm is concolor with the back and has only a narrow streak of gray down the forearm instead of the whole outer surface being gray, as in the previous forms; the thighs are less gray than in the preceding species, being encroached on by the color of the back; traces of the color of the back extend on the upper surface of the tail for nearly one-third its length; the underparts are a lighter and brighter hazel, inclining to Ridgway's orange-rufous.

Skull.—Besides its smaller size, the skull of *Sciurus hippurellus* is distinguished by its heavier rostrum, broad expanse of the premaxillæ on its upper surface, and more slender zygomata. (Fig. 12, *b*.)

Measurements.—See table, page 29.

Specimens examined.—Three—two from the Landak River and one from the Kapuas River, below Tyan, western Borneo.

Remarks.—This species is quite closely related to the squirrels from Sumatra and the Malay Peninsula and very different in point of coloration from the race inhabiting northern Borneo.

SCIURUS GRAYI Bonhote

1867. *Macroxus rufogaster* var. *Borneensis* GRAY, Ann. Mag. Nat. Hist., 3d ser., XX, 1867, p. 283—not *Sciurus borneoensis* (Müller and Schlegel), 1839–44.

1901. *Sciurus hippurus Grayi* BONHOTE, Ann. Mag. Nat. Hist., 7th ser., VII, February, 1901, p. 171, foot-note.

Diagnostic characters.—A member of the *Sciurus hippurus* group, with the color of middle line of the back very dissimilar to the sides, closely resembling burnt sienna, sparsely grizzled with black.

Color.—This species differs in color from *Sciurus hippurus* described above as follows: The color of the sides is found on the top of the head as far forward as the eyes, instead of to the ears only; the mid-dorsal area for a width of 30–40 mm., beginning at the base of the neck and extending on base of the tail above, differs in color from the sides, being like Ridgway's burnt sienna, sparingly grizzled with black; the grizzle of the upper neck and sides consists of black and tawny, instead of black and raw sienna; the black of the tail has more of a brownish cast; the underparts are dark as they are in the squirrel from the Malay Peninsula; the outer side of the forearm is gray, as in the Sumatran and peninsular forms, and not concolor with the sides, as in the other Bornean species.

Skull.—The skull of *Sciurus grayi* closely resembles that of *Sciurus hippurellus*.

Measurements.—See table, page 29.

Specimens examined.—Six, from northern Borneo.

Remarks.—This species is very distinct from the other known members of this group and shows more differences from the west Borneo form than the latter does from Sumatran and Malay Peninsula forms.

External and cranial measurements of squirrels of the Sciurus hippurus group.

Name.	Locality.	Catalogue number.	Sex and age.	Length of head and body.	Length of tail.	Length of hind foot with claws.	Greatest length of skull.	Zygomatic breadth.	Interorbital constriction.
				mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
S. hippurus	Malay Peninsula, Trong	84,433	Female, old	260	255	63	60.0	36.6	19.5
Do	do do	83,490	Male, adult	240	260	62	58.4	34.9	18.5
Do	do E. coast Johore.	112,731	Female, adult	258	255	63	57.5	35.4	20.9
S. hippurosus	Sumatra, Tarussan Bay	141,031[1]	Female, old	265	270	68	60.8	37.8	20.0
Do	do do	141,032	Female, adult	252	270	66	58.5	35.0	20.5
Do	do do	141,033	do	255	275	65	59.6	36.0	19.5
Do	do Besitan River	143,399	Male, adult	260	250	62	57.8	34.0	19.6
S. hippurellus.	Borneo, Kapuas River, below Tyan.	142,272	do	250	250	61	55.7	34.2	18.2
Do	Borneo, Landak River	142,273	Female, adult	240	260	61	56.1	34.2	19.5
Do	do do.	142,274[1]	Female, old	250	280	63	58.5	35.7	19.7
S. grayi	do Mt. Salikan	83,932	Male, adult			63	57.4	34.2	19.4
Do	do do	83,933	do.			61			
Do	do Baram River	105,892	Female, adult			60		33.8	19.2
Do	do Baram Dist	141,468	Male, adult			58			
Do	do do	141,469	Female, adult			58			
Do	do Mt. Dulit	141,470	Male, adult			61			

[1] Type.

A NEW CALAMARINE SNAKE FROM THE PHILIPPINE ISLANDS

By LEONHARD STEJNEGER

Curator, Division of Reptiles and Batrachians, U. S. National Museum

Dr. E. A. Mearns, U. S. A., has recently forwarded to the National Museum a single specimen of a *Calamaria* which appears to be undescribed. It is in very bad condition, but the characters are so well differentiated and so unmistakable that I do not hesitate to describe it.

CALAMARIA MEARNSI, new species

Diagnosis.—Ventrals about 250; a distinct postocular; diameter of eye less than half its distance from the mouth; 5 upper labials; frontal slightly longer than broad, more than twice as wide as supraocular, shorter than parietals; mental separated from chin-shields by first pair of lower labials.

Habitat.—Mindanao, Philippine Islands.

Type.—Cat. No. 36991, U. S. N. M.; Tangob, N. Mindanao, June 10, 1906; Dr. E. A. Mearns, collector.

Description of type specimen.—Rostral well visible from above; frontal slightly longer than broad, more than twice as broad as supraoculars, shorter than parietals; one preocular; one postocular; diameter of eye less than half its distance from the labial edge (commissure); five supralabials, third and fourth entering eye; two pairs of chin-shields in contact with each other; mental separated from chin-shields by first pair of lower labials; scales in 13 rows; ventrals, 251; anal entire; subcaudals, 12 pairs; tip of tail rounded. Color (in alcohol), dark brown above, each of the two outer scale rows broadly tipped with pale yellowish; parietals and prefrontals with pale yellowish markings; a pale yellowish collar, about two scales wide, seven scale rows behind the head; a pair of large pale spots on sides at base of tail; tip of tail pale except the extreme point, which is dark; underside uniform pale with ends of ventrals like back; a dark brown line along middle of underside of tail.

Dimensions.—Total length, 270 mm.; tail, 8 mm.

Remarks.—This species is apparently most closely allied to *Calamaria everetti* and the *C. pavimentata* group, but differs from the latter in the number of supralabials and from both in the much smaller eyes. The large number of ventrals distinguishes it at once not only from these Calamarians but from all the other species known from the Philippines, and in fact from most of the species of the genus. *C. gracillima*, from Borneo, exceeds it in having 300 and more ventrals, but it lacks preocular and has no distinct postocular. *C. collaris*, from Celebes, has from 232 to 265 ventrals, but has a much larger eye and a very different style of coloration. In the latter respect *C. mearnsi* agrees essentially with the *C. pavimentata* group.

ADDITIONAL NOTES ON MEXICAN PLANTS OF THE GENUS RIBES

By J. N. ROSE

In 1905[1] I published a synopsis of the Mexican species of *Ribes*, in which sixteen species were enumerated. Seven of these were described as new. By oversight *Ribes brandegei* of Lower California was omitted. Beautiful specimens of this species have been sent in recently by Messrs. E. W. Nelson and E. A. Goldman from Lower California. Since the publication of my paper, two Californian species, *R. indecorum* and *R. viridifolium*, have been found in northern Lower California, while the new species which is described below has come to hand from Durango. Messrs. Nelson and Goldman have re-collected *Ribes quercetorum* in Lower California and *R. ceriferum* has been collected in flower for the first time by Dr. E. Palmer in Durango. A new species from Hidalgo, *Ribes altamirani* Jancz.,[2] was described in 1906. No specimens of this species have been seen by me, but it is said to be related to *R. affine* and *R. ciliatum*.

Recently also *Ribes viburnifolium* has been reported from one of the islands off the coast of California, and this species is therefore not confined to Mexico, as was supposed.

RIBES MADRENSE Coville & Rose, sp. nov.

Second-year branches light brown, somewhat pubescent; young growth green, densely pubescent; prickles either simple or 3-branched, at first yellow, in age brown, 4 to 5 mm. long; petioles 1.5 to 2 cm. long, pubescent; leaves more or less deeply 3-lobed, the lobes strongly toothed or cleft, more or less glandular and pubescent on both surfaces; peduncle pubescent; bractlets broadly ovate, obtuse; calyx tube 3 mm. long; lobes of calyx 6 mm. long, slightly hairy; petals about half as long as the calyx lobes, dark red; style glabrous; ovary glabrous; mature fruit not seen.

Collected by Dr. E. Palmer near Quebrada Honda, Durango, May, 1906 (no. 215).

Type.—U. S. National Herbarium, no. 571237.

The only Mexican species which is at all near this is *R. microphyllum*, a plant distinguished by its stouter prickles, smaller leaves, somewhat different flowers, etc.

[1] Contr. Nat. Herb. **8**: 295–300.

[2] Bull. Acad. Crac. **3**: 10. 1906.

MORKILLIA, A NEW NAME FOR THE GENUS CHITONIA; WITH DESCRIPTION OF A NEW SPECIES

By J. N. Rose and Joseph H. Painter

MORKILLIA Rose & Painter, new generic name

Chitonia Moç. & Sessé; DC. Prod. **1**: 707. 1824, not D. Don, Mem. Wern. Soc. 4: 317. 1823.

The genus *Chitonia* has hitherto been unrepresented in many of our larger herbaria, or has been represented only by material collected many years ago. Until now it has rested upon a single species, *C. mexicana*. Fruiting specimens of this were collected in 1905 near Tehuacán, Mexico, and in 1906 fruit and flowers were obtained from the same place. Some years earlier, Mr. E. W. Nelson had collected in northern Mexico a very different species, which is here described as new.

The name *Chitonia* of Moçino & Sessé is a homonym of the *Chitonia* of D. Don, and hence a new name is here proposed. The genus is named *Morkillia* in honor of Mr. W. L. Morkill, general manager of the Mexican Southern Railroad, who has taken a great interest in and has contributed to the development of our explorations in southern Mexico.

MORKILLIA MEXICANA (Moç. & Sessé) Rose & Painter

Chitonia mexicana Moç. & Sessé; DC. Prod. **1**: 707. 1824.

Shrub 3 to 5 meters high; young branches densely pubescent; lateral leaflets 4 to 7 pairs, oblong, obtuse or at first acute, shortly petiolulate, very pubescent on both surfaces, 3 to 5 cm. long; flowers large and showy, 8 to 9 cm. in diameter; petals strongly notched, deep purple; fruit 4 to 5 cm. long with 4 lateral wings, these free at the top and more or less incurved, dehiscing when mature, exposing the red aril of the seeds; seeds white with a black spot at the tip.

Specimens examined.—Puebla: near Tehuacán, Rose & Painter, August 30, 1905 (no. 9992); J. N. & J. S. Rose, September 2, 1906 (no. 11278); also C. A. Purpus, July, 1905 (no. 1315).

MORKILLIA ACUMINATA Rose & Painter, sp. nov.

Near *M. mexicana*, but leaflets paler above, ovate and acuminate, more densely pubescent, flowers much smaller (6 cm. or less broad), petals less notched, and fruit broader and nearly truncate at apex.

Collected by Mr. E. W. Nelson on road over mountain between Victoria and Jaumave Valley, altitude 240 to 750 meters, May 31, 1898 (no. 4444).

Type.—U. S. National Herbarium, no. 332515.

THE "WEBSTER" RUIN IN SOUTHERN RHODESIA, AFRICA

By EDWARD M. ANDREWS

I. General Description

The ruin here described was discovered by the late Mr. Dunbar Moody in 1892, who led the trek from the Orange Free State into this country in that year. It was shown me in May, 1906, by Mr. W. Webster, whose farm it adjoins, and who extended much courtesy and kindness to me while in this district. The ruin I named after him. It is situated in the M'Shangaan country close to the present kraal of Ichickwanda, who is, I believe, the head Induna of M'tamas, the paramount chief of the people. It is about 25 miles south of Melsetter township, which in its turn is distant from Umtali some 85 miles. It is on a high plateau, which runs on a ridge one mile due northeast, where it commands a magnificent view of the surrounding country and has water close by on either side. The farm is the property of J. M. Oeper, Esq., former surveyor general of southern Rhodesia, and I am greatly indebted to him for permission to explore and excavate, subject, of course, to the approval of the government.

The ruin is nearly circular, the defect being on the northwest side, where also is the rounded entrance. It is built in two tiers, the second tier rounding off on top, just to the northeast of where the entrance or passage comes out, in a "curl" which rises about a meter above the tier in question.

The height of the lower tier on the northwest side is on an average 1.8 m. and is built with some care, of stones mostly flat and averaging 30 pounds weight. There is small attempt at bonding, the courses are bad and no mortar has been used. From this tier the fall back to the second tier is 2.1 m., and that brings one against the "curl," which from the level on the northwest side resembles a small tower or cone (pl. I). The height of the second tier on this side is 1.2 m.

On the southwest side the height of the lower tier is 2.8 m., from the level of the ground the fall back to the second tier being also 2.8 m. The height of the second tier on this side is 1.3 m. The diameter of the building at its greatest width is as nearly as possible 16 meters. It is generally in very bad repair, caused in a great measure by two enormous wild fig trees growing from the southeast side, and which apparently have their roots right through the building. Very small portions of the original wall of the lower tier are to be seen, so great is the damage done. In fact this applies to the lower tier on all sides with the exception of the northwest side, which, as already stated, is in the better repair.

The entrance is about one meter wide, and has large rough flat stones for steps, placed along its whole length, which is 5.2 m., gradually rising to the top, and coming out due west of the "curl" and almost against it.

The center of the building on top, and inside the walls of the second tier, has apparently been filled in with earth. Many rough planks of some very hard wood, averaging about 40 cm. in width and 7.6 cm. in thickness, were found lying here. Their original lengths must have been about 2.5 m. All have oval holes cut along the sides, and they must have been fastened together, as the iron hasps still remain in many of them, the hasps being in very fair condition considering the great dampness always prevailing just where they were found. Whether these planks had anything to do with the structure I cannot say, but it almost seems as if they had been made to serve as a sort of platform across the earthen portion, already referred to, inside the walls. In some cases the wood is in excellent condition.

The "curl" is oval and its greatest length is 2.6 m. In the center, on top, lies a large flat stone, giving it the appearance of being capped. The greatest length of this stone is 1.3 m., with an extreme breadth of 1.1 m., and its general thickness is about 10 cm. For what purpose it was placed there, whether for ornament or not, does not appear.

On the northwest, or entrance, side the lower tier rises from a built foundation of large, rough, flat stones, in all about 1.5 m. in height. In taking the height of the lower tier on this side the height of the foundation was not included.

Close against the entrance are two monoliths, one large and one small (pl. I, 1). The larger one, of slate, is 2.4 m. high, 40 cm. wide, and 10 cm. thick. The smaller one, close against it and Y-shaped, is 1.2 m. in height, 30 cm. wide, and 10 cm. thick. These two monoliths stand directly in front of the entrance.

Almost due north of these entrance monoliths, at a distance of 2.3 m., there are two more monoliths close together, the smaller one 1.2 m. high, 20 cm. wide, and 10 cm. thick; the larger one 1.7 m. high, 30 cm. wide, and 10 cm. thick. At a distance of 1.8 m. due

ENTRANCE TO RUIN, WITH MONOLITHS. THE SECOND TIER WITH "CURL" IS SEEN ON TOP ON THE LEFT

THE "CURL" WITH LARGE STONE OR CAP

west of the entrance monoliths there is a single monolith 1.4 m. high, 30 cm. wide, and 10 cm. thick.

As already stated, two monoliths are directly in front of the entrance; therefore any one approaching the entrance must pass between those monoliths to the west and north of the entrance.

At a distance again of 7 m. west from the entrance is what I believe to be a large grave, having at its east end a monolith 1.8 m. high, 40 cm. wide, and 10 cm. thick. A small monolith is also found on the southwest side of this supposed grave.

Close by there is another grave having a monolith at the south end. This has fallen. It is 2.4 m. high, 40 cm. wide, and 10 cm. thick. Five meters northeast of the entrance there is another large grave, with a large slate monolith at the south end, 3 m. high, 50 cm. wide, and 10 cm. thick. A large number of what apparently are graves are on the northwest and west sides of the building, these graves being piles of stones of various shapes and sizes, but the whole grave nearly oval in shape.

Now that the undergrowth and tiers have been cleared away, several other monoliths of various sizes are seen lying around. The supposed graves apparently face without regard to any particular direction.

The remains of several native huts lie a short distance from the ruin, but they must be quite recent. Cement flooring, in most instances about 7.5 cm. thick, is found in all of them; also the small circular place for cooking, which can today be seen in any native hut.

Though I made careful search, I have so far seen nothing of the nature of a real debris heap. True, sherds of common pottery lie around the outskirts of the building, but I do not think they can have any connection with the ruin itself.

From enquiries made among the natives in all directions, I can learn nothing respecting the history of the ruin, though the natives generally appear to regard it with some reverence. It is scarcely surprising that I am unable to procure information on the subject, for no native appears to know anything of the past, unless that past happens to have been within his own personal recollection. Some there are, but very few, who do know something of the history of their people, mythical or otherwise, mostly the former, but it is very difficult to get them to speak of it in any way to a white man.

The photographs I am sending were taken for me under most trying conditions of light and shade by Mr. J. Myers, of the British

South African police, and I am indebted to this gentleman and his comrades for much courtesy and kindness.

II. NOTES ON THE ICHICKWANDA RUINS

These ruins are situated one mile northeast of the Webster ruin and on the same ridge. They are on the extremity of the spur, the descent being sharp and some hundreds of feet into the valley below. They consist of one main ruin surrounded by four other inferior ruins or rough stone enclosures.

I spent some fourteen days clearing and working all of them, but the result was again practically nothing. However, an account of the main ruin may be of interest, as in some respects it resembles the famous pit dwellings at Inyanga, so clearly described by Dr. Randall MacIver in his work "Mediæval Rhodesia."

The structure is as near as possible circular, being built of large stones, averaging 70 pounds in weight, which in some instances are slightly dressed. It consists of one circular room, or kya, extremely neatly built up. This room is exactly 4 meters in diameter, and the height of walls, as they presently stand, average 2.7 m. There is no attempt at bonding, and no mortar has been used. The walls of the dwelling are in perfect condition inside, with the exception of the very tops; clearly stones are missing here. Roots of the trees have grown out and in among the walls, forming sorts of clamps, and just at present binding them very strongly.

Measuring from any point inside the dwelling walls to the extreme edge of the outside wall, the average is about 6 m. wide. Many of the stones—in fact, many tons in all—have rolled down, yet portions of the original walls are here and there to be seen.

The entrance faces due south and on the west side is beautifully rounded, though the east side has been destroyed, but I am of the opinion that this side was not rounded, for the reason that the east wall of the entrance inside is not rounded, while the west again inside is rounded. The length of the entrance is 3.5 m. and the width in no part exceeds 70 cm. Inside the dwelling on the north side two stones, each about 70 cm. apart and in equal distance from the top and floor, project from the wall, and were no doubt used as steps. The diameter of building is about 14 meters.

One can only suppose this to have been the dwelling of human creatures; it could not have been built as a cattle kraal, as bullocks, at any rate, could not have gone through the entrance, and surely such enormous walls were not necessary to enclose cattle. It may have been built for a fort; certainly the situation encourages the idea, though at present the ground around is densely wooded. I excavated to bed-rock and carefully searched through the soil, but fragments of common household pottery only were found, and certainly not enough of that to lead one to suppose the place had been inhabited for any length of time.

The outlying stone enclosures may or may not have been used as cattle kraals. I could find no evidence of human occupation in any of them.

(CHIPINGA, S. MELSETTER, S. RHODESIA, *November* 19, 1906.)

III. WORK DONE ON THE WEBSTER RUIN.

THE TEMPLE.

October 13, 1906.—Commenced sinking a shaft 2.3 m. in diameter through the earth in the center of the upper tier. At 30 cm. came upon quantities of common household pottery sherds, undecorated. At about the same depth found an iron spear-head, the head being 20 cm. in length and 2 cm. broad at the widest part, the iron shaft being 10 cm. in length, having four sides. Again, at the same depth, a circular iron shaft of spear 20 cm. long; also at the same depth one iron arrow-head 15 cm. in length and 1.5 cm. in width at widest part. They are in fair condition, the earth where they were found being seldom dry. At 1.6 m. from the surface came upon stone rubble, showing every indication of considerable depth, probably to the level of the foundations. This rubble much resembles the rubble foundations found in the majority of Rhodesian ruins.

The shaft is sunk nearly against and due southeast of the "curl." My reasons for sinking through the ruin were: (1) It appeared to me that should the large flat stone, or "cap" of the "curl," have any connection with an underground chamber I was far more likely to cut that connection, besides doing infinitely less damage, and (2) there would undoubtedly be a great saving of time and labor.

October 15.—Having on the last day's work sunk through earth 1.7 m. in depth, proceeded this morning to remove the rubble. I worked through this rubble, which had a depth of 1.2 m., when I again came upon the same sort of soil, which is in reality decomposed sandstone. I worked through this to a depth of 70 cm., and at that depth it strongly resembles bed-rock, though I am not at all certain at present that it is.

This makes the depth of the shaft 3.6 m. From very careful measurements taken from the outside, corresponding with the level of the top of the shaft and that of the level at the base of the building, I found the measurements to be very much the same, and from this I am led to suppose my shaft is not yet down to bed-rock.

Unless with a lot of extra work, it is hardly possible to go deeper, as the rubble keeps continually falling and making work dangerous. As the building, excepting on the northwest side, is so much destroyed, owing to the roots of the large trees going through the walls, and as it can only be a matter of a very few years before the whole structure tumbles to pieces, I have decided to cut a section through the building from the northeast side and come through onto the shaft. This will leave three sides of the structure as they were. On removing the cap on the "curl" I found rubble underneath, and the question arises as to why this cap was placed there. At present I can only conclude it was for ornamentation. During this day's work, no articles, not even potsherds, were found.

October 16.—Commenced cutting a section from the northeast side, towards the center of the structure. On working away the stones which had fallen from the second tier, and once within the circle of the second tier, found that though the outer walls had at least some attention paid to the building of them, yet the inside was composed of rubble thrown in and earth to fill up the crevices. About 2 m. inside the second tier came upon two monoliths firmly embedded in the ground, and each slanting to the northeast at an angle of about 45 degrees; they were one meter apart. At this point sherds of very common household pottery were also found, and at the same level and almost in the same place a piece of green glass was found. This glass much resembles the green glass found at Dhlo-Dhlo last year, only this piece is very much thicker and looks as if it had at one time formed a portion of a bowl. This glass is about 5 cm. in size either way. Almost in the same place and at the same level was found a thin piece of glass about 11 by 6 cm., which has a thin coating of what is apparently silver on both sides, but from the different hues I take the glass to be colored. One piece of decorated pottery only was found, and that had the cord pattern on it. Large bones and teeth of animals were found in fairly large quantities at all levels. Two "fuba" game stones and one grain-crushing stone were also found among the rubble.

October 17.—Continued the section through to the center, working away the top portion right into the "curl." Removed the large stone on top of same, and worked downwards, with interesting results. At about one meter down came upon fragments of a very fine earthernware or porcelain bowl. From the fragments by me—

RUIN FROM NORTHEAST SIDE SHOWING SECTION BEING CUT. THE SECOND TIER AND "CURL" ARE PLAINLY VISIBLE

RUIN AND MONOLITHS FROM THE WEST

and they would form nearly half the bowl—I should imagine the bowl to have been somewhere about 22 cm. in diameter, with a depth of about 3 cm. It is as nearly as possible the color of terra-cotta, about 5 mm. thick, on the average, and is enameled a bluish color on both sides. The enamel has very much cracked, as if it had been fired too much or from some other cause. I can venture to give no name to it, as I have seen nothing of the sort before. As I have yet to go a considerable depth below where these interesting

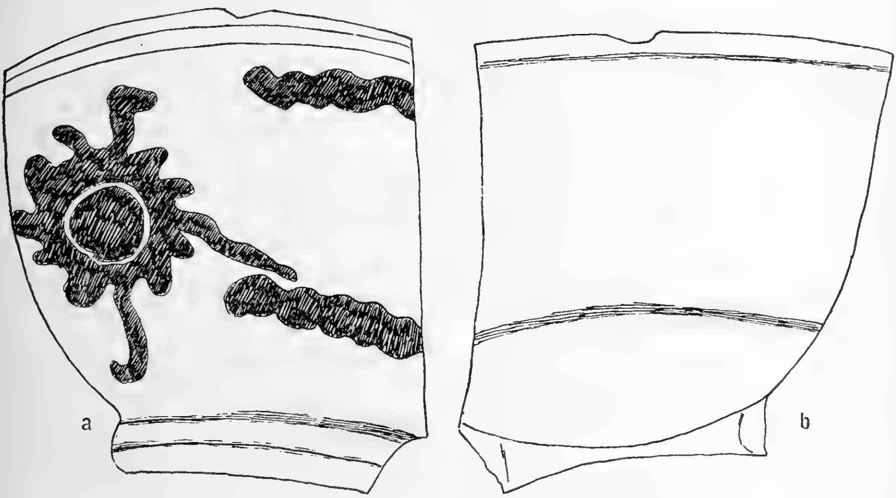


FIG. 13.—Piece of Nankin china bowl; *a*, outside; *b*, inside. Two-thirds natural size.

pieces were found, I hope I may be lucky enough to find some of the remaining pieces (fig. 13).

Almost in the same place and at precisely the same level, I came upon a very fine piece of a Nankin china bowl. The bowl must have stood about 11 cm. high, with a diameter of 17 or 20 cm. It is beautifully marked, the glaze is perfect, and the coloring very fine. I may be lucky enough to come upon other portions of the bowl later on. Another piece of pale-green thick glass, about 4cm. square, was found in the same place, and from its shape I judge it to be a portion of a bowl; also a small iron ring, or bangle, was found about the same spot. Also another piece of that colored glass, an exact copy of which is here given (fig. 14). It also has that silvery covering on it, and it makes one wonder whether such glass could have formed some portion of a sacred lamp or something of that sort.

The sherds of pottery found in this particular part were of very much better make, many of the sherds being colored with hematite and plumbago; one piece only was decorated, and that with thick vertical lines, in batches of three, about 5 cm. apart.

I must here state that it is quite impossible to work the building in an even manner, as the top sides must be slanted away in order to prevent the rubble falling on those working below.

FIG. 14.—Piece of cloudy glass; exact size.

The Nankin and other stoneware were found a meter below the center large stone of the "curl." Towards the top of the second tier and near the "curl," burnt wood supports were found, two or three of which I am keeping. These again form a link in other Rhodesian ruins, they being found in all.

October 18.—Heavy rain; work impossible.

October 19.—Resumed work on section. Nothing of importance to note except the finding of another fragment of Nankin china, which was found between the rubble, in almost the same place as the other. It is a different design from the other piece, and I fancy it is a portion of a plate. The design is that of flowers and the coloring is very fine (fig. 15).

FIG. 15.—Fragment of Nankin china; exact size.

In the drawings all those portions which are white are supposed to be pale blue; the designs are very dark blue, nearly black, while the lines are shaded accordingly.

Figure 15 is of the fragment of Nankin china found today and the exact size. The inside is quite plain, having no designs or lines of any sort. Its thickness is 4 millimeters.

October 20.—Continued section, bringing work through and under the "curl," to the head of the steps. A quantity of common household potsherds were found, but only one piece decorated. Four iron arrow-heads, as per illustrations (fig. 16), were found; also one iron axe-head; one iron bangle, also shown, was found; one piece of an iron hoe and one piece of light yellow glass, similar to that found before. All these articles were found nearly on the surface, round and about the "curl."

October 22.—The work of excavation being now well under the steps and considering it not worth while going any farther in that direction, I concluded my work on the interior of the building. I then commenced work on the "addition" to the building, removing from the outside and going inward the whole of the added wall. There can be no doubt the portion removed was built after the main

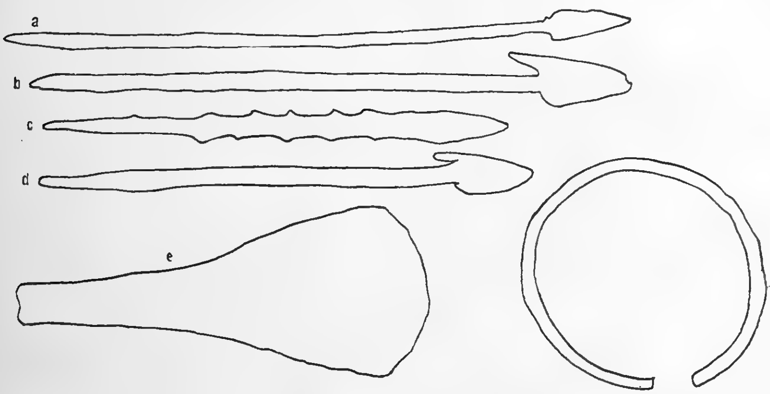


FIG. 16.—*a*, *b*, *c*, *d*, iron arrow heads; *e*, iron axe head; iron bangle. One-half natural size.

building had been standing some time, and I imagine 50 or 60 years to be the limit of age of this addition.

The monoliths referred to earlier in this report as having been found two meters inside the circle of the second tier were, I think, placed there as supports, as two more were found adjoining, all being the same distance apart, namely, one meter.

I have sunk below the surface or floor of the building in two or three places, but in every instance I have found bed-rock and nothing else. I have therefore decided to suspend work on the Temple for the time being at any rate, and turn my attention to the graves lying around, or rather to the northwest and west of the Temple.

There are plain indications of natives' habitations of no great age close around the building, and I will cut a section through these before leaving. Sherds of common pottery are lying all over the place, but I can see no indications of any defined debris heaps, though a good deal may, of course, have been washed down the sloping hillsides.

That the Temple is the work of a negro race admits of no doubt, and though the style of architecture in general is different from other Rhodesian ruins I have seen, yet there can be small doubt that a negro race built it, and the presence of Nankin china among the rubble walls conclusively proves it cannot be earlier than the beginning of the XVIIth century or, at the very earliest, the very end of the XVIth century. The work of the builders is very poor, and were it not for the outer walls, one would say without hesitation that the ordinary Rhodesian native would on the whole make a better job.

The only objects found among the stonework of the addition were one iron arrow and two iron arrow shafts, a piece of yellow glass,

FIG. 17.—*a*, shaft of iron arrow head; *b*, iron arrow head; *c*, shaft of iron arrow head. One-half natural size.

and a small piece of iron with screw through same, which were found on the top of the wall of the addition. These are shown in figure 17.

October 23.—Commenced excavating at the foot of the northwest or entrance wall; worked carefully among the monoliths, going down to bed-rock, and though sherds of common household pottery were found, the only other articles found were an iron spear-head and portion of a native hoe, as given in the illustration. Having found no skeletons in the main building, I was almost sure they would be found outside, among the monoliths, but up to the present nothing of the kind has been discovered. And yet what object could the builders have had in view, in piling up heaps of stones and placing monoliths about them? It is quite true the M'Shangaan of today does not make his grave as these are made, if they really are graves. He is content to bury his dead in a recumbent position, without regard, so far as I can find out, to whether the body faces east or west, and then around the actual grave he places one thin line or circle of stones. Within a few hundred yards of this spot M'Shangaan dead in considerable numbers lie around, but they are the dead of the ruling chief, Chikwanda, or of his people, and under these circumstances I have no right to disturb them. I am carefully turning over the ground around the building and supposed graves, but without success in any form up to the present.

The absence of debris heaps, and I am convinced there are none, proves to my mind it could not have been an ordinary dwelling ground, though there are a few native huts, or the remains of them, about, but they are quite recent. I have come upon no copper wire, brass wire, or beads of any description, nor do I think I am likely to.

The green glass I firmly believe to be the same as the Portuguese use at the present day in making the demijohns for their vino. I was comparing it with one a few days ago and it resembles the

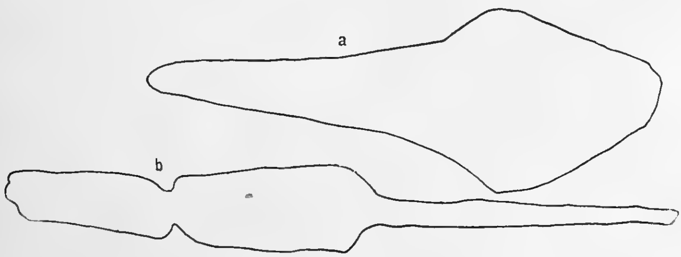


FIG. 18.—*a*, portion of hoe; *b*, iron spear head. One-half natural size.

demijohn very nearly. The iron things found today are shown in figure 18.

October 24 and 25.—Continued turning over the ground round the ruin and among the supposed graves. Only a few iron articles were found, as shown in figure 19. Quantities of sherds of common household pottery were found lying about, but none with decoration of any sort among them. I also turned over the flooring of three old huts, but nothing was found in either of them, with the exception again of common potsherds, and an iron spear used on the heel of an assegai and bound round with iron. The natives of the present day use the same thing. It is for sticking the assegai in the ground; also for digging out small roots, etc.

October 26 and 27.—Heavy rains on these days and quite impossible to do any work; in fact, the rainy season appears to have set in.

October 29.—Commenced work on the supposed graves, which work carried me on till November 7. As already stated, the graves are piles of large and small stones piled together, being in shape more or less oval, and each one has a kind of retaining wall, so as to keep the stones above in their places. In all, I have opened up fourteen of these graves, and each one with a similar result—sherds of very common household pottery and bones of antelope only. In one instance only were any other articles found. These consisted of a piece of thick green glass, evidently a portion of the mouth of a large bottle. It appears to have been painted, but I can form no idea with what. From the same grave came a pottery spindle whorl.

Among the old huts or remains of huts around, I found two or three iron articles, these being classed with those articles found outside the main ruin.

As I can see nothing to be gained by doing further work on this,

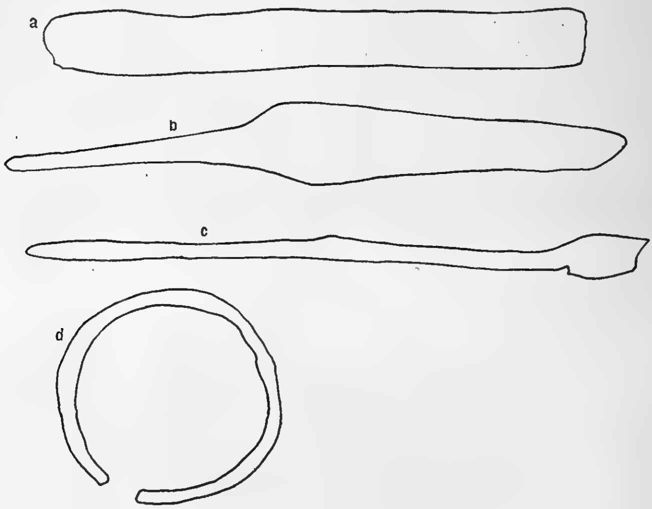


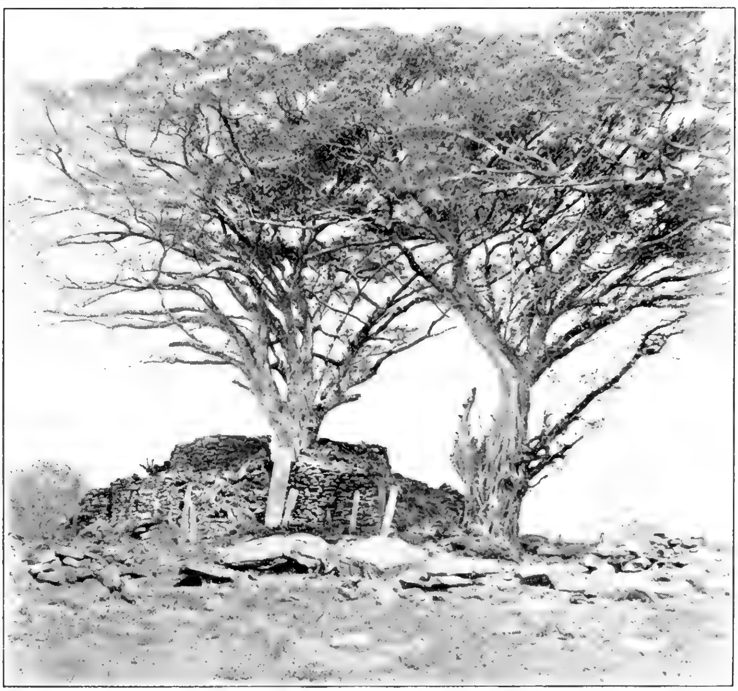
FIG. 19.—*a*, piece of iron nearly 6 mm. thick, much corroded; *b*, iron spear head; *c*, portion of iron arrow head; *d*, iron bangle, much corroded. Reduced one-half.

the Webster ruin, I may be allowed to draw my conclusions concerning the ruin generally.

It has been stated by one of the British South African police stationed at Chipinga, who was asked to make a report on the place before leave was granted me by the government to do some work, that the structure was a fort. This statement appears to me to be quite erroneous. I can see no point about the place which could lead any one to suppose it could have been or ever was intended to have been a fort.

The exceptional style of building, the monoliths, as it were, guarding the same from the northeast to the southwest, the graves, which are only found between these same points of the compass, go

GRAVES ON NORTHWEST SIDE OF RUIN



RUIN FROM THE WEST. THE FIG TREES

to prove very strongly to my mind that it was built for and has remained a sacred enclosure, the main building probably having been what I have termed it all through these notes, a "Temple."

In the Temple, more especially in the vicinity of the "curl," broken sherds of pottery were found; also bones of antelope (large). 'Round about the monoliths, bones and sherds were again found, and in all the graves opened there was the same result. Throughout not one skeleton has been found. Under the circumstances, is it not possible that cremation was in vogue among these people? It appears to me to be by no means an improbable solution of the mystery.

I have already remarked that the work throughout is that of a negro race, and again that the work cannot be earlier than the end of the XVIth century.

In case any argument may crop up, now or in the future, let me again state that the fragments of Nankin china were found in the main walls, or, to be exact, in the main wall of the "curl," quite a meter below the surface.

Again, the fragments of terra-cotta porcelain were found much in the same place; though I can give no name to it, yet in some respects it has the appearance of "coalport."

UMTALI, S. RHODESIA, S. AFRICA, *December* 20, 1906.

THE BORORÓ INDIANS OF MATTO GROSSO, BRAZIL

By W. A. COOK

In November, 1900, while in Goyaz, Brazil, the writer received a communication from the Smithsonian Institution, through Doctor Orville A. Derby, of São Paulo, requesting photographs and descriptions of the aboriginal tribes of Matto Grosso and a collection of objects made and used by them.[1] I here give some account of the journey to Matto Grosso and of the manners and customs of the Bororó tribe.

Senhor Antonio Candido de Carvalho, a Brazilian explorer of large experience and influence and thoroughly acquainted with the region to be traversed, had arrived at Goyaz with his light traveling caravan, and the evening before the communication from Mr. W. H. Holmes of the Smithsonian Institution was received, had invited me to accompany him on a visit to the villages of the Bororó Indians scattered over that extensive region of Matto Grosso between the capital of Goyaz and Cuyabá, the capital of the State of Matto Grosso. I did not hesitate to accept the invitation, for with Senhor Antonio as a companion and guide, whose influence over many of the Bororó tribe was great, I would be at much advantage in doing the work desired.

As Senhor Antonio Candido had his equipment, I needed only to buy a mule to carry my baggage and a horse to ride upon, a tent, raincoat, riding boots, and some bright colored cloth, knives, beads, fishhooks, mirrors, handkerchiefs, etc., to trade with the Indians.

We left the city of Goyaz, nearly 700 miles from the Atlantic coast, on November 17, and, following the divide between the great river systems to the north and south, traversed between nine hundred and a thousand miles before reaching the city of Cuyabá, in Matto Grosso.

We rode nearly 600 miles before we began to meet with the Bororó Indians. The last 60 or 70 miles was through an exceedingly wild and almost unknown region of forest and dense bush that made traveling almost like pushing through a network of barbed-wire sieves, where we were constantly raked and torn, and were drenched by the daily thunderstorms.

[1] The photographs, implements, and other objects gathered by Mr. Cook among the Bororó Indians are in the U. S. National Museum.—EDITOR.

On January 9, 1901, we reached the Rio Ponte de Pedra, about 45 miles north of its junction with the Rio São Lourenço, where the latter bends nearly westward. Senhor Antonio had recently thrown up here a simple palm-branch, stake-walled ranch, near an important village of the Bororó tribe on friendly terms. The place is called Ta-Dare-Mano Paro, "potato bank," or "place where tubers grow."

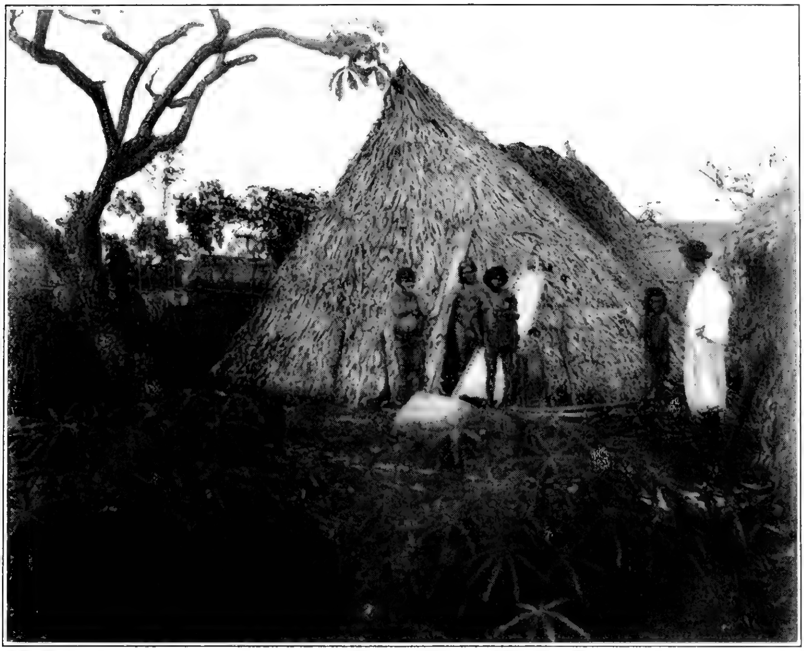
As soon as our arrival became known our ranch, scarcely more than an open shed, began to fill rapidly with our painted friends of all ages and sizes and of both sexes, who came to observe us and to see the marvelous things we had brought from our enchanted world. They pour in upon us regularly at the break of day and stay faithfully till the shadows of night begin to deepen; and though coming and going constantly, we always have our full complement. If we open one of our pack-mule trunks, our visitors are on the alert to handle whatever may strike their fancy. If we eat, every mouthful of food is closely scrutinized, and whatever we may do is observed with the closest attention. They recline on our boxes, sprawl on our tables, lean against the posts, squat on the ground, and hunch down around our pot as it boils, always leaving a patch of paint wherever they sit or lean. Some smoke, others lazily pick and eat the kernels from a roasted ear of corn, others nibble the white cheese-like heart of a diminutive palm that furnishes a considerable part of their food; the boys devour bits of fish roasted black, or shoot at a stick or a stump with their crude bows and arrows. Just outside the door men gossip, vacantly gazing, but never once toward the one they address, or they ask us a few questions in the limited language that we know in common. The women and children usually form an outer fringe to this group. Whenever there is prospect of obtaining beef our congregation is at once largely increased. They never steal anything that is distinctively ours, though they will take anything we have bought of them if they have an opportunity.

The long, straight, coarse black hair of both males and females hangs in a tangled mass about their shoulders, except above the forehead, where it is kept chopped off to form bangs. Nearly all the single young plaster these bangs with a sort of red putty made from the small yellowish-red fruit of the burity palm and fish oil, and the same paste is used to paint the entire body. Boys and girls who are esteemed by their parents also have the foretop arranged in this way, and a few of the latter who are regarded with special favor have it plaited with a layer of beautiful red feathers. Again, young men, as well as boys and girls, who are liked by their parents have their shoulders gummed and plaited with white feathers, somewhat resembling a shirt-vest. Other young men wear feather armlets. One woman was covered with white feathers from head to foot, with a brilliant plume in her hair. All young men and boys wear suspended from a hole in the lip, bored during infancy, a kind of chain called nogodau, about six inches long, made of flat oval-shaped bits of shell, terminating in a red feather. The older men have a plug in this hole, for if left open it causes difficulty in drinking. The young males wear around their loins a girdle over an inch wide woven from long tongue-like palm leaves. All males who have reached the age of puberty are obliged to wear a shield called bá. A large crescent is worn on the breast, suspended from the neck. A charm, worn on the breast and greatly prized, is made of rows of monkey teeth bound to bamboo rods sometimes eight or more inches long. They are loath to part with this, having received it as a present, and for other reasons. The huge horn claws of the tatou canastro (*Priodontes gigas*) are also worn on the breast and are much esteemed. Coils of square plaited cord hang around the neck, and 10 or 15 yards of hair cord, made of the hair torn out of or cut from the heads of mourners during funeral ceremonies, are worn by men wound around the head. Beyond the ornaments above described the males dress or bedeck themselves only on special occasions.

Females above six to nine years of age also wear a sort of corset, made of the inner bark of a tree, especially tanned and prepared, and which encircles the body twice or nearly so. It is much like a bottomless cheese-box or bushel measure, and evidently at first causes much discomfort. Another strip of bark about six inches wide and four feet long, so prepared that it is almost like cloth, passes between the legs from front to back. With this gear, a female is considered properly dressed. When she becomes old, she often discards the corset and uses the soft bark instead.

When a handkerchief or a small piece of cloth was obtained from us, the men tied it around the head or waist, with the points in front and the fly falling behind. The females and boys would hang it shawl-like over the shoulders or around the waist.

There were thirty huts in the village that encircled in a very irregular way, facing in every direction, a very large hut that stood in the center and was called baehytu. Bae (by) is the name of the ordinary family hut. This baehytu is the bachelors' hall, the headquarters of all the unmarried men, the workshop where the men make weapons and ornaments and instruments, the dining-



BORORÓ HOUSE, BRAZIL

INTERIOR OF BORORÓ HOUSE, BRAZIL

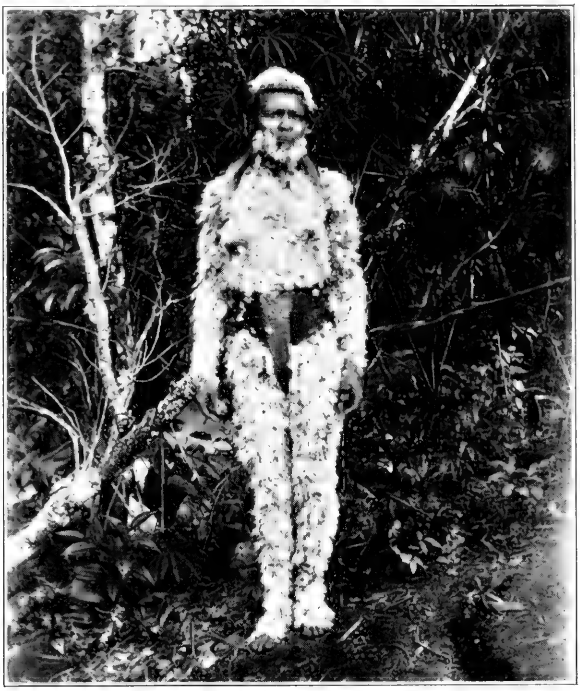
room, the town hall where most public functions occur, and the club where visitors are received and entertained. The baehytu of the Ta-Dare-Mano Paro village is about 50 by 30 feet and 18 or 20 feet in height. The ridge-pole rests on three tall posts, and shorter posts support the principals. To the rafters and to the wall posts are tied a few bamboo poles, and upon these are bound, rather sparingly, long palm branches with tongue-like leaves to keep out most of the rain, the wind, and sun. It is entered through an opening at each end, like a hole in a haystack, and within is always damp, gloomy, and foul smelling. The family huts, built of the same material, are mostly like a roof resting on the ground and strongly resemble an old haystack with a hole eaten in each end, though occasionally the hut is raised a little and woven palm-branch tongues form a basket-like wall. Deep gloom reigns within these huts. They are made dark that they may be free from flies, and are dens of rubbish and filth. Stuck into the roof are bows and bundles of arrows, war clubs, fishing gear, and instruments and ornaments not in use at the moment. The occupants of this human lair are sprawled on a palm-leaf rug, with a log of wood four inches in diameter for a pillow, and sleeping, or gnawing an ear of corn, a bit of fish or vegetable, or sitting tailor fashion, making beads, arrows, or other objects, or kneeling by the little fire preparing food. When the filth becomes unbearable or disease is prevalent, they do not trouble to clean house, but simply abandon and burn the old and build a new one on a clean spot. Usually the entire village moves to a new place some distance away.

Two families nearly always occupy one hut, and sometimes three or four, or even five. Each family has its camp-fire, which, however, is very small, since the gathering of firewood costs the women much labor. Just over the fire and about two feet above the ground is a small wooden rack where fish and meat and vegetables are roasted or baked. About five feet above the fire is a second and quite large rack, the family pantry, where perishable food is preserved by the smoke of the fire below. Each family or individual has its mattress or rug of long woven palm leaves, and each one a pillow made by binding a small roll of green banana stalks or a length of wood three or four inches thick.

A day or so after our arrival a child of seven or eight years belonging to one of the leading families died. This gave us an opportunity to witness a strange ceremony.

A loud, deep, prolonged hee-aw, ho-o, ah-ah, was bellowed by a quartette of naked, painted, and feathered savages, squatting slightly in unison with each note, and shaking huge calabash rattles. This was accompanied by the wailing chant of a chorus of women standing just behind the quartette and waving fans to keep away the flies. The snort of two huge flutes, the barking of the calabash trumpets, the lament of the savage mother, her body besmeared with her own blood, kneeling by the corpse of her child, the hairs jerked from her head, half a dozen at a time, by a female crouched behind her, the lamentations of the father, with his hair clipped, as he kneeled on the other side of the body and recited the virtues of the deceased loved one, and the low mournful chant of female relatives or friends as they slashed their legs and arms, or even their entire bodies, with sharpened shells—this was the drama that unfolded itself one beautiful summer morning as we crept into the baehytu of the Ta-Dare-Mano Paro village. The little daughter of a chief had been summoned from her earthly bae to wander with the bope (evil spirits), and the funeral ceremonies were in progress.

When a Bororó dies, his body is wrapped in the palm-leaf rug which has served as his bed and is carried to the baehytu, where the spectacle described above makes night and day hideous until the first sunset after death; then as the sun goes down the chorus becomes hushed, and the bundle of remains, with a nine-foot pole passing through the roll, is carried to the public play-ground just outside the baehytu, and about ten inches of earth heaped over it. Here it rests a week that the flesh may separate from the bones, and each evening at sunset the sorrowing family and friends gather around the little mound, their faces toward the fading light, and murmur a low chant, pleading the virtues of the departed one. Every evening, also, water is thrown on the little mound to hasten decay. The day before the remains are to be resurrected is again a gala time. A bamboo whistle brilliantly decorated with feathers is blown at intervals to summon the bope, while within the baehytu the man who invites the bope to resurrect the body is decorated and fêted. He wears a skirt of palm leaves hanging loosely from a belt, over his shoulders a cloak of the same material descending below the waist, and over his head is a veil of slender palm leaves to prevent his recognition, and his name must not be spoken. On his head, to represent the setting sun, is a pariko, an ornament of brilliant feathers of the makaw and parrot. Thus arrayed, he dances up and down sideways like a crab, while a companion and a rear guard execute similar movements. After a time, accompanied by all the males, they leave the baehytu for the play-ground just beyond the village, all dancing as they go. Here the soul-representa-



BORORÓ WOMAN ADORNED WITH FEATHERS

BORORÓ METHOD OF CARRYING WITH HEAD STRAP

tive and his body guard, exhausted, sit on the ground to rest, and a substitute, or rather those who are to represent them, his brother tribesmen, proceed to call the bope by offering some tobacco or other delicacy. Soon one offers himself as a bope-representative by dropping on all fours and creeping slowly toward the caller, emitting a noise like the grunt of the tapir; and finally, springing to his feet, he rushes with outspread arms to the center and quietly stands on a spot prepared for him. Others repeat the performance, until five are in line in the center. They are smeared from head to foot, hair and all, with a coat of clay. Black streaks are painted around the eyes and other decorations added, and the five bope again drop on all fours, and the caller (still acting as adjutant for the decorated soul-representative, standing in the path to the village) beckons and calls as before. At the same time the remaining band seeks to drive the bope to the village by pushing them with instruments used to frighten evil spirits, jumping, screaming, and swinging their arms. But the bope advance slowly, constantly making their squeaky grunt. Just as they enter the village path a man suddenly springs up before them, frightens them with a yell, and they wheel and begin creeping away from the village. The drivers then become more frantic than ever to prevent the escape of the bope without resurrecting the body. Finally the bope again head toward the village, enter the path, suddenly spring to their feet, mount their "horses," fellow red men, gallop into the village, dismount, squat around the burial mound, and claw the earth with their fingers. But this is only a feint of what is to happen later, and the body still lies covered, while the bope retire, having finished their part in the drama for the present. A large fire has now been kindled, and in order that the spirit of the departed may not return to haunt the family his belongings are passed piece by piece to the adjutant, who hands them to his master, who throws them in the fire while they both dance and waltz around it. This done, the soul-representative and his adjutant sit astride the grave, and having called the father of the deceased, who crouches beside them, he fortifies him against evil spirits by passing a hand over his head and face, whispering and blowing in his mouth and ears, after which he deposits all his paraphernalia, except the pariko, upon the grave. The day's performance concluded, all the males sit in two groups just outside the baehytu, and the daily feast is served by the females.

Early next morning the bope-representatives resurrect the remains by means of the pole, carry them to the river, scrape and wash the bones and pack them in a basket, keeping the skull separate when they wish to decorate it. They say that the resurrectionists are not called by men, but directly by the bope, and no one is supposed to know who they are.

When the village awakes to find the bones already prepared, the din is again unchained, the mother and female friends again slash themselves from head to foot, wail, and daub their bodies with black paste made principally from a fruit called genipa-pa, while two men sit on a palm-leaf rug and decorate the skull with a layer of bright red makaw feathers. This weird drama continues all day with little interruption, the players and singers relieving one another from time to time. And if some of their brethren from a neighboring village should visit them, the bakororo, as this noise is called, may continue all night and all the next day. Finally the concert ceases, and at sunset the basket of bones is laid away in the little cemetery outside the village, where the bope will take possession of them in due season, though only the priest is supposed to know when. Through constant howling during the bakororo, the family of the deceased become so hoarse that they cannot speak above a whisper, but the drinking of clay water, they say, relieves them.

As the Bororó is "very bad," they say, he is doomed forever to wander and suffer in the lower regions and be subject to constant eviction. He takes up his abode in the bodies of certain fish and mammals, and when the creature dies the spirit must seek a new dwelling and be exorcised from the bodies of fish, fowl, or beast by the priest before the meat can be eaten. To eat it without this ceremony would cause sickness and death. Not every creature, nor even every member of certain species, is inhabited by a bope. Its presence is indicated only by certain markings or other peculiarities. In exorcising the bope the priest faces and calls upon the sun with loud yells, ecstatic jumping and trembling, slapping the fish, spitting and blowing into its mouth. Corn also must be exorcised, as they say they were once made desperately sick by eating it without this ceremony. Only the priests are exalted to an abode with the sun at death ; they are not chosen by men, but by the bope. It comes about somewhat in this manner : Some day a Bororó may be taken with a fit, and a priest of the tribe will be called to determine the disease and to say whether he will live or die. After consideration he may say to those present, "Piadudu [humming-bird] is in deadly combat with a bope. If he surrenders to the bope he will become a priest, but if he continues to resist he will die." If Piadudu recovers, it is considered that he has given himself up to the bope, and is therefore qualified for the priesthood. But the certificate of priesthood seems to lie largely in the ability to throw themselves at will into a savage ecstacy.

When a Bororó is ill, a priest is called to determine whether he will recover or die. On entering the hut and looking at his sick tribesman and concluding that he will probably die or should die, he will count his fingers, and each time he touches one finger will repeat, "Meri, meri, meri, meri, meri, bi," meaning that the sick man will see five suns, five days, and die, or he may say, "Nadua, nadua, nadua," etc., "bi," meaning sleep, sleep, etc., five days, and die. If at the end of this time he still lives, the executioner, sent of course by the priest, will suddenly appear in the hut, sit astride his stomach, and strangle him to death, for the reputation of the priest must be maintained. The priests are probably responsible for not a few deaths. They are the bane of life in the tribe. They must nurture the delusion that they can communicate with and have influence in the other world and power to avert or cause evils and calamities. They are therefore on the alert to take advantage of any propitious occasion to prey upon the superstitious fears of their fellow-tribesmen. They are freely supplied with food by their tribesmen in order to retain their good will.

The Bororó seem to have no idea of God as the Christian understands Him. They consider the sun as the fountain head of majesty and power and even of beneficence, and as the abode of the great priests who have passed to the spirit world and fear him. Bope means spirit or disembodied soul, but they seem to have no idea of a good spirit. The bope, who are evil spirits, must therefore not be offended though they must be driven away. To drive the spirits off, they use a bull-roarer, a peculiar instrument made of a slab of wood about half an inch thick, shaped something like a fish, and of varying size, hung by a long cord from the end of a stick like a fishing rod, and swung round and round through the air. As it swings and rapidly revolves, it sends forth loud sounds to a surprising distance, pitched from a sepulchral moan to an unearthly shriek, the wail rising and descending the scale according to the rapidity of the swing or the size of the instrument. To hear several of these roarers at once certainly produces most unusual sensations, particularly when operated, as we heard them, during a tropical storm amid the play of the lightning, the crash and roar of thunder, the falling floods, and dismal gloom. No female is allowed to see this instrument under pain of death. New ones are made as occasion demands, and they are burned immediately after their need has passed. We entered the baehytu as some of these roarers were being made for the funeral prelude. There was deep silence, and the word bope was whispered low and mysteriously. Certain warning calls are given some hours in advance of the time for bringing the roarers into use, and, hearing these warnings, the females enter their huts, close the openings, and hide their heads. The roarers are manipulated outside the village up and down through the bush. We had difficulty in securing examples of these instruments. They were brought to us at night securely wrapped and amid the greatest secrecy, every precaution being taken to make sure that we would keep them where there would be no possibility of a female seeing them. We also had much difficulty in obtaining the base flute which is played only over the bones of their dead. A captain said to me, "That is a very bad instrument; you must not take it. If you do you will never return."

The Bororó are expert swimmers and are fishermen of the highest order. One mode of fishing is to swim out into the river, three or four miles above the village, with a net called buke, like a great bag, its mouth secured to two parallel rods nine to twelve feet long, bound together at their ends. When one or more fish are seen, the mouth of the sack is opened by springing the rods apart, and with wonderful dexterity the fish are bagged and the mouth of the net quickly closed by allowing the rods to spring together. The fisherman then plays the game, especially if it be large; gradually rolls the net over the rods till the fish cannot move, brings it to the surface and kills it with a club, which he trails by a cord from his neck. The fish is now taken from the net, strung on a cord, and floated along with the club. Sometimes two or more fish of twelve or fifteen pounds will be taken at one catch, or maybe one weighing as much as the man himself will be bagged in this way. A Bororó will remain in the water an hour or two continuously, and return ashore with six or eight large fish. They have learned to turn their bodily strength to the greatest account while in the water.

Another method of fishing is with a bone harpoon, to which is secured a long cord and a short detachable bamboo staff. With this the fisherman enters the water, and, finding a large fish in the shadow of a rock, following it with great expertness if it moves, he plunges the harpoon into it even at a depth of fifteen or twenty feet, while the staff detaches itself and remains in his hand with the end of the cord secured to it. The fisherman now returns to shore and plays the fish until he lands it.

Another method, when fish are scarce, is for one gang of men to enter the water with their sack nets, three or four miles above the village, form a chain across the stream and make a great commotion and drive the fish downstream to a point near the village where another gang with sack nets awaits to bag the game. Sometimes they fish at dead of night, but as a rule they rarely leave the village after dark except in war.

Late one cloudy afternoon we had the pleasure of seeing the Bororó play Mano, the name of the small banana-like plant used in this game. It seems to be a close imitation of some of the performances of ants. Indeed, the imitating of nature occupies a large part of the Bororó life. Early in the day they went up the river and cut many of these plants, which grow three or four feet high, floated them down on rude bamboo rafts, carried them to a point about 600 yards from the village, and placed them in two piles, one for each of the two parties into which every village is divided—the Xeráede and the Ta Nagarêde. Each group prepared its material by cutting off the tops of the mano, leaving a spongy stem about eighteen inches long, and when all was ready each made its pile into a huge wheel. This was done by two men for each wheel standing face to face, about five and a half feet apart, with two long, strong, parallel cords between them, reaching from the ground up over their shoulders, for binding the material into a wheel. The mano was then piled in between each pair of Indians acting as posts, and when the weight pressed too heavily upon them, they were supported by other Indians leaning against them, back to back. When the mano was all in place the cords were drawn over the top and tightened. The wheels were next laid flat on the ground and a string of men pulled with all their strength on each of the four ends of the cord for each wheel, while others pounded the spongy mass so close that it could not burst. Each wheel was again set upright to be seized and hurried off in the mad race for the village. But the Bororó must do things decently and in order, so a Ta Nagarêda man, with much ceremony steps quickly over to the Xeráede, takes a man by the wrist, trots him around his wheel and stops in front of it, meaning by this that his wheel is delivered to its party, and the same ceremony is repeated by the other side. Each man who has now been presented to his wheel and his wheel to him, politely introduces others of his own party just as he himself was introduced, until all surround their own wheels. At a given signal each group seizes its wheel, throws it up on its shoulders, and runs pell mell in a race to the village. Each squad of these human ants tries to keep its wheel upright as it sags this way and that, or finally rolls over on the carriers, to be quickly straightened up, and rushed along again, each crowd endeavoring to keep the lead. As they entered the village one wheel burst through the side of a hut. Finally both parties threw down their wheels in the public square at nearly the same moment, greeted by the applause of the whole village. They now all retired to partake of their evening feast and left the wheels to be torn apart by the women and children for use as pillows. A feast always ends the game, each party eating separately.

When about to go on a fishing trip, especially when fish are scarce, or on a hunting expedition, they sing the bakaroro, which seems to be a hymn in praise of the beast or fish that is to be hunted the next day. It is sung within the baehytu after nightfall and several times a week when food is scarce. The good qualities of the animal are named, and how well it will be treated and the use that will be made of it when taken. In this anthem, the man again exhibits his imitative qualities by attempting to reproduce the animal sounds which he has been most accustomed to hear. Frogs and toads are especially favored. While visiting the Kogy ao Paro village, about twenty miles away, we spent a night in the baehytu, and listened to the bakaroro at close quarters. The din, the darkness broken only by the red light of the fire that cooked our beef, the stagnant air, the noise of this squad of human beings reproducing the sound of everything that dwells thereabouts, made one imagine that he had passed from the earthly to the unearthly. After the bakaroro, the singers went outside the baehytu, and having cleared away the black earth, brought ashes and made animals in relief on the ground, especially the tapir which they were to hunt next day. This is also a tribute of honor to the animals. They also sing the bakaroro in honor of a visitor. As they had seen men hunting on horses and admired this method, they formed a horse in relief with a man mounted on it.

It is always the man (mêdo, from meri, the sun) who does the light work, while the woman (arêda, from are, the moon) is the beast of burden. She it is who must provide food for the family. Her lord may go fishing or hunting, and if he brings home something, well and good, but if not, he expects to find food on returning to his hut.

There appears to be no regular marriage ceremony among them. The girl is betrothed before reaching the age of eight or ten, and married at from ten to fourteen or even younger. She becomes betrothed by her would-be husband presenting to her parents a specially fine fish, or some animal whose flesh is much esteemed, he of course having made known in some way what he wishes in return for such a present. When he would take his betrothed to himself he makes a second similar present to her parents and they deliver her to him in his hut. Parents try to betroth their daughters while still young. We saw no large families, the largest number of children any one mother had being three. Extremely early marriage and the fact that the wife is driven to the baehytu whenever she displeases her lord may be reasons for small families. They hold their wives in utter subjection through fear of the bope and of the baehytu. A few of the leading men have two wifes, an old one, and perhaps also a girl wife. Only men who have killed the spotted tiger, or performed some other feat of valor, may take a second wife. Children are not born in the village. The prospective mother hides herself in the bush until the child is born, and then returns to the village or is led back by female friends who go in search of her. It is common for children, especially girls, to nurse until they are six or eight years old, so large indeed that they can stand on the ground and nurse while the mother also stands. Younger children will climb up the mother's leg to reach her breast. They nurse at any time, the mother paying scarcely any attention to the child, who does absolutely as it pleases. The Xeráede and the Ta Naragêda in each village eats, fishes, hunts, works, and plays by itself. A man of the Xeráede cannot marry a woman of his own party, but must select one from the Ta Naragêda, and vice versa. The Bororó have a tradition that the Xeráede once possessed all things that the Bráede, civilized men, now possess, such as knives, axes, blankets, etc., but as these things brought calamity, they were obliged to abandon them. There is evidence that these Indians are made up of what was once two distinct tribes. The Xeráede tradition might indicate that the Bororó may have come in touch with the civilization of the Andean slope in ancient times.

The men are usually faithful to their wives—that is, they do not abandon them, especially where they have children, though at rare intervals one will become dissatisfied with his areda, drive her from the hut, and he himself take up his abode elsewhere. Fights between two married men are not uncommon through one intriguing with the other's wife. The conflict begins when the outraged husband berates the guilty one in shouts so loud that the whole village can hear, and the latter in turn at the other end of the village returns the compliment with interest. As they warm in their anger they emerge from their huts and finally get together, while all the men, women, and children of the village form a ring around them to enjoy the sport. The fighters tumble, kick, and bite, and scratch with the poisonous spur or spine from the tail of a fish similar to the skate secured to their little fingers. Their endurance is marvelous and the fight may continue many hours, sometimes nearly all day, both parties constantly uttering their yells. The defeated party leaves the village, and the woman becomes the victor's prize.

The Bororó, like most other savage men, look to nature to furnish them with nearly all their food. About the only thing they cultivate is a little yellow corn, and even this with great difficulty, for they have no steel instruments. They are communistic, and therefore little inclined to attempt anything extensive in the way of agriculture or to provide a stock of food, for if one family should do this, it would only be to divide the harvest with the rest of the community and leave themselves with nothing for the morrow. There is thus no incentive for labor except when hunger drives them in search of food. The Bororó is therefore acquainted with about everything edible in his environment, and he knows when and where and how to obtain it. The river is by far his most important source of supply, and when fish are abundant in December, January, and February he grows fat. The rest of the year he is obliged to look largely to the woods for food, though he is a more expert fisherman than hunter, and individual families wander abroad through bush and forest along the rivers. As to fruit and vegetables, the palm is his never failing friend. It will always provide him with something when naught else can be found. At every season of the year he may obtain the white cheese-like heart of a diminutive palm. The fibrous trunk of two or three other varieties, pounded and wrung out, gives a starchy, liquid-like milk which, when boiled in a clay pot and mixed with the yellow fruit of the burity, makes good soup; or he may dry the starch and make it into bread. Another palm, called burity by the Brazilians, yields a yellow fruit bigger than a very large plum, which he eats with a relish, though we considered it very insipid. Still another species furnishes an unfailing supply of nuts about the size of a goose egg. This he throws into the fire for a few minutes, then removes the thin outer shell, and scrapes off and eats a thin insipid substance very much like the inner bark of the slippery elm. He then splits open the remainder of the thick shell and obtains a white woody kernel, which he eats raw or pounds in a wooden mortar and makes into a loaf to be wrapped in a large leaf and baked into bread in the ashes. This is considered quite a delicacy. The palm also furnishes material for his bows and for the shafts of his arrows. The long tongue-like leaf furnishes a silk or band of strands called bokigo, which he rolls into a single strand as he sits cross-legged on the ground, and by twisting this strand with others he obtains cording with which to make his fishing nets, harpoon lines, etc. From the ground he digs two or three varieties of the potato family, which he boils. Corn is eaten as roasting ears or cut from the ears and boiled. They use no salt. The large ant bear is considered the most valuable of all creatures. Nearly every part of its body is utilized. When discovered it is driven to the village for slaughter in order to secure its blood. After this comes the tapir, which is also greatly esteemed. When food is plenty they eat nearly all the time when awake, and even rise several times in the night to take a little food. While we were in the baehytu at the Kogy ao Paro village we saw 33 men devour upwards of 25 gallons of boiled shelled corn within an hour and a half, and they had been nibbling roast ears all the morning. The two men who had accompanied us from the Ja-Dare-Mano Paro were induced to eat from every pot as they were brought in one at a time. They seem never to get full, and will eat as long as there is anything to be had. While at work making bows and arrows and ornaments, they are nibbling food, if they can obtain it. They eat the corn mush squatting and standing around the pot, using large oyster-like shells or broad leaves as spoons.

Their language seems quite free from clicks and from deep gutturals. The names given to animals are often in imitation of the sound produced by the animal. Ki, for instance, means tapir, and is a close imitation of the note of this animal; pobu means river or water; pobu camahina is great river; meri rutu, sunset; adugo, spotted tiger or ounce; and aigo, brown ounce. Báekimo is the negative; Boe by báekimo means "Indian die not"—"I will not die."

They are wonderful whistlers and seem able thus to communicate whatever they otherwise would by speech.

All the fine and ornamental work is done by the men. A great deal of time and labor is spent in making seemingly unimportant articles, and the time consumed in shaping and burnishing an arrow is astonishing, generally the larger part of two days. The shell ornament worn around the neck is made by the reciprocating motion of the point of a sharp instrument of flint or of iron or steel, if they can obtain it, fastened near the center of a roughly shaped shell. A fire is kindled in the same way by boring a wooden rod into another bit of wood. When holes have been made in bits of roughly shaped shells they are strung tightly together on a cord or rod, and a bit of grinding stone is rubbed up and down their edges till they are of equal size. A wide belt is made by placing two bamboo rods in the ground two feet or more apart and winding around them the thread that is to serve as warp, placing each thread close beside the preceding one. The woof is then worked with the fingers and a wooden blade.

Wild cotton is pulled out and rolled into thread by hand just as the fiber of the palm is made into cord.

Bows and arrows are used in war, but they prefer to fight at close quarters with a club of heavy wood, shaped nearly like a baseball bat, about 3½ feet long. A smaller club is also used as club or sword.

The ceremony of naming baby boys is very interesting. Early in the morning the family and friends, with the little one coated and ornamented with feathers of crimson and white, accompanied by a priest, take up a position on the highest ground near the village. At sunrise, the priest pierces the lower lip of the embryo warrior with a long, sharp, bone-pointed instrument made for the occasion and decorated with many-colored feathers. At the same time he pronounces "Piadudu" or the name of some bird, animal, or object whose name the child is to bear. "Piadudu," softly repeat the family and friends, and thus "Piadudu," humming-bird, a favorite name, becomes the name of the child. They are very jealous of their names and will not make them known to any one not belonging to their tribe, always when asked responding "parduko"—I do not know. A woman is totally disfranchised and can scarcely consider herself a citizen. She is merely an adjunct to the man.

These savages, although so filthy in their habits, are sometimes quite sensitive to noxious odors, and we were sometimes much amused to see them rush about in disgust to escape some disagreeable odor.

They make no canoes, but are satisfied with small rafts sufficient to float their cocoanuts or mano down the river.

The Bororó are the tallest of any South American Indians I have seen. I do not remember one man under five feet seven inches, and they are sometimes six feet three or four inches tall. They are full faced, the nose well shaped and not large nor particularly flat, nor are the cheek bones especially prominent. Many of the children and some of the young men are quite handsome.

The tribe is supposed to number between five and ten thousand souls. We visited eight villages and settlements.

CACTUS MAXONII, A NEW CACTUS FROM GUATEMALA

By J. N. ROSE

In 1905 Mr. Wm. R. Maxon, an Assistant Curator in the National Museum, was detailed by the U. S. Department of Agriculture for field work in Guatemala, and while there he acquired a fine series of living specimens of a new cactus, which is here described. The same year Prof. W. A. Kellerman of the Ohio State University sent another specimen of the same from Guatemala. Some of the larger plants have flowered and fruited, which has enabled me to ascertain fully the characters and preserve specimens for the herbarium. The two photographs here reproduced are of the same plant taken at an interval of just 24 hours. Among other things they show how quickly the fruit is pushed out.

CACTUS MAXONII Rose, sp. nov.

Plate VI

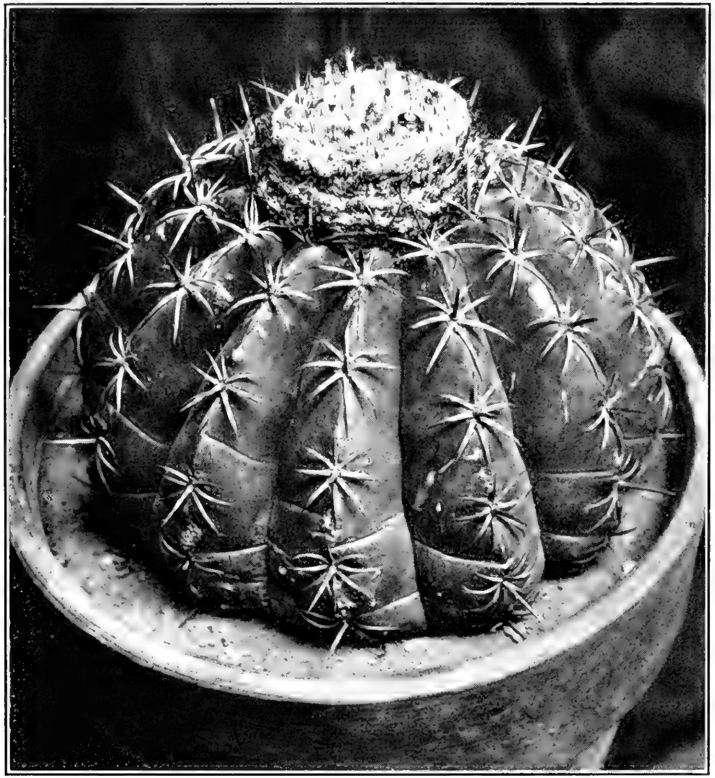
Plant body simple, deep green, broadly cone-shaped or short-cylindrical, 10 to 15 cm. high; cephalium rather small; consisting of a mass of white wool and brown bristles; ribs 11 to 15, rather broad, either mottled or plain; spines generally 9, rarely only 8 or sometimes with several smaller ones making 11 in all, the central one (rarely 2) short, standing nearly at right angles to the rib, 1.5 to 2 cm. long; radial spines spreading or even recurved, pale red or rose-colored with a whitish bloom, but when old colored amber; flowers small, rose-colored; fruit narrowly oblong or club-shaped, red, resembling that of Mamillaria; seeds black, shining.

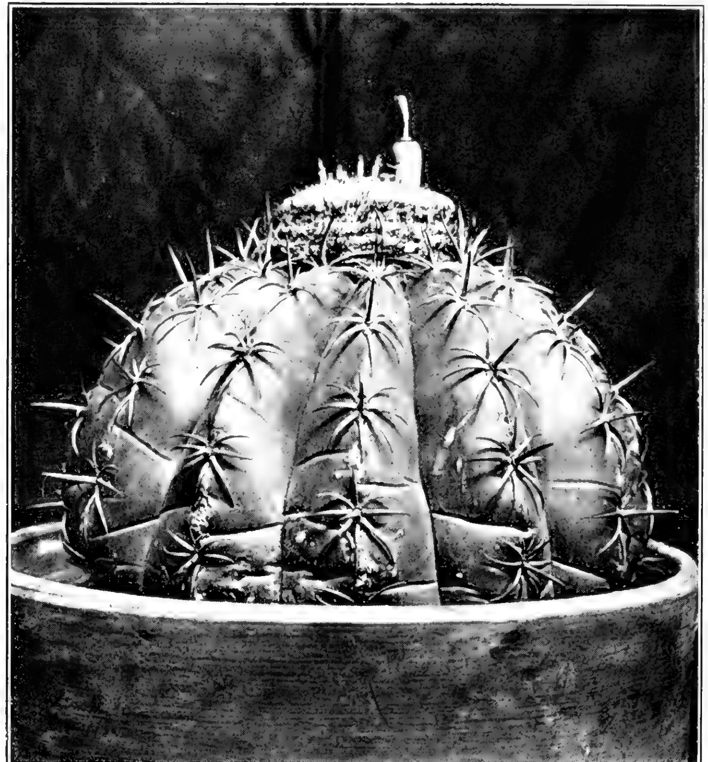
Collected in Guatemala near El Rancho by W. R. Maxon in 1905 (no. 3766, type) and near Salama, January 22, 1905 (no. 3378); also collected in Guatemala by Prof. W. A. Kellerman. The description is drawn up from living plants in Washington.

Type in U. S. National Herbarium no. 535,059.

Perhaps nearest *C. neryi* but with more ribs, with a smaller cephalium, and with the spines almost always 9.

This species is of the Melocactus type, under which name it would be placed by most cactus students. My reasons for using the generic name Cactus will be explained in full in a more extensive paper on the Cactaceae to be published later. It is well known that the late Otto Kuntze not only referred Melocactus to Cactus but also Mamillaria and even Cereus, Echinocactus, and similar genera. The present use of the name Cactus is not to be understood as countenancing this wholesale reduction of genera, which in my view has no justification whatsoever.





CACTUS MAXONII, PHOTOGRAPHED AT AN INTERVAL OF 24 HOURS

ON THE CLASPING ORGANS ATTACHING THE HIND TO THE FORE WINGS IN HYMENOPTERA

By Dr. LEO WALTER

WITH TWO FIGURES IN THE TEXT AND FOUR PLATES

(From the Zoölogical Institute of the German University in Prague, under the direction of Professor von Lendenfeld. Published with the assistance of the Hodgkins Fund of the Smithsonian Institution.)

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I. Introduction

It has long been known that in many four-winged insects peculiar clasping contrivances are present which unite the fore and hind wings during flight in such a manner that they together form a homogeneous surface and act like a single wing. Thus, according to Kolbe (1893, p. 255), many crepuscular and nocturnal Lepidoptera—the Sphingids, Noctuids, Geometrids, Cheloni, and Pyralids—possess a thorn or a group of bristles on the upper side of the base of each hind wing, which inserts itself into a small band-shaped structure formed of hair-scales situated on the under side of the corresponding fore wing near its base, and thus effects the union of the two wings. In the Sesiids, Cicadids, and Trichoptera this union is brought about by the hind margin of the fore wing folding over and interlocking with the inversely folded front margin of the hind wing. The highest development of such a clasping apparatus is met with in the Hymenoptera. In these, fine chitinous hooks, arranged in a row, arise from the front margin of the central part of the hind wing and insert themselves into the involuted hind margin of the fore wing. A closer examination, particularly from the morphological point of view, has up to the present never been accorded these structures, and Professor von Lendenfeld suggested to me in the autuumn of 1902 to investigate these structures. I may be permitted here to express my sincere thanks to my highly esteemed chief and teacher, not only in giving me the inspiration for this work, but also for his friendly support during its progress, and to the Smithsonian Institution for a grant from the Hodgkins Fund of that Institution which enabled me to obtain the material and instruments necessary for the work.

II. Historical Review

In nearly all entomological text-books and monographs on Hymenoptera, the wing-clasping apparatus characteristic of this order is mentioned and its function briefly explained; but in none of these works is there a discussion of the anatomical conditions involved, nor do good figures, particularly of transverse sections, exist of these structures. Chabrier's figures (1822, pl. x, fig. 4; pl. XIII, fig. 8) of a transverse section through the fore and hind wing of a bumblebee are so primitive and diagrammatic that it is obvious that the author never saw a transverse section of a hymenopterous wing under the microscope.[1] Other figures of sections through the contact region of hymenopterous wings are unknown to me. The very small number of existing works which treat especially of the clasping hooks of the Hymenoptera are for the most part purely systematic. The best and most detailed of these is Miss Staveley's (1860, Trans. Linn. Soc., London, vol. XXIII, pp. 125-138, pls. 16, 17). She describes the shape and arrangement of the hooks of the hind wing and the groove formed by the hind margin of the fore wing, and gives, based on the morphology of the costal vein and the grouping, topographic position, form and number of the hooks, a key for determining the species which will be discussed in the systematic part of this paper. Staveley mentions (1860, p. 125) that the clasping hooks have already been described and figured by older microscopists without giving any exact bibliographical references. Two smaller treatises, by Gray (1860, p. 339-342) and Staveley (1862, p. 122-123), are only supplementary to the above-cited work. Recently the variability of the number of hooks in the bee have been studied from the biometric standpoint (Koschewnikoff, cited from Bachmetieff, 1903, p. 41-43).

[1]An instructive diagram of the wing connection (surface view) is given by Sharp (1895, p. 494).

III. Material and Methods

In my investigations I used dry, spread, material as well as material preserved in liquids; the former for surface preparations of entire wings and for sections in celloidin, the latter for the thin paraffine sections necessary for a detailed study under higher powers. Surface preparations are easily made by simply inclosing the entire wings in Canada balsam. To remove the air retained in the veins, which is very disturbing, it is advisable to boil the wings in chloroform before mounting. If this be done until no more air bubbles escape from the cut ends of the veins, and the wings are then immediately transferred to the balsam, the veins will be found free from air. To obtain sections 20 to 30 microns thick, showing the mode of connection between the fore and hind wings (pl. IX), I had to embed in celloidin, because paraffine wing-sections of this thickness fall to one side as soon as the paraffine is dissolved, the wings being very thin. The celloidin, of course, keeps these high sections, standing on edge, securely upright. The objects destined to be embedded in celloidin were treated in the following manner: The insect, killed in fumes of chloroform or cyanide, with the wings hooked together, was carefully spread and, according to its size, was dried for a half or a whole week. Then I removed the two wings, still hooked together, along with the accompanying part of the thorax, boiled them in chloroform, and brought them through absolute alchohol, ether and alcohol, and ether into celloidin. Standing proved superfluous in my celloidin sections. For the study of finer details, particularly the linking of the hooks and hairs, thinner stained paraffine sections are necessary. The most favorable specimens for this kind of examination are the still soft and pliable wings of young, newly emerged imagos. I fixed wings of this kind with good success in alcohol and sublimate and also in 4 per cent formol, and preserved them in 70 per cent alcohol. The chitin of the wings in older individuals is very hard and brittle, splinters in cutting, and rarely yields good sections. I tried several times to soften hard chitin by means of diluted nitric acid, Javelle water, and caustic potash, but had no success worthy of note. A relatively good method of making hard chitinous parts somewhat more pliable is the one used by Hoffbaner (1892, p. 583), of allowing the wings to remain in paraffine a long time. The best stains for the paraffine sections proved to be concentrated aqueous solution of eosin and concentrated alcoholic solution of safranin, which were taken up fairly well by the chitin. Hæmatoxylin (Delafield's) rendered good services in the staining of pupal wings.

LIST OF THE SPECIES OF WHICH WING SECTIONS WERE STUDIED

(Of the species printed in italics paraffine sections, permitting a closer study under higher powers, were made. Of the others, only thicker celloidin sections were studied.)

Tenthredinidæ: *Tenthredo mesomelæna L., Sirex gigas L.*

Ichneumonidæ: Exetastes fornicator Grav., Campoplex aculeator Holmgr., Dyspetes prærogator Thoms., Henicospilus ramidulus Steph., *Rhyssa persuasoria Grav., Ichneumon fusorius L.*

Formicidæ: Formica rufa L., *Camponotus ligniperdus Mayr.*

Fossores: Pompilus viaticus Fabr., Ammophila subulosa Latr., *Crabro vagus Fabr.*

Vespidæ: Vespa crabro L., *Vespa rufa L., Vespa vulgaris L.*

Anthophila: Anthrena ovina Klug., *Xylocopa violacea Latr.,* Megachile ericetorum Lep., *Bombus lapidarius Walk., Bombus terrester L., Psithyrus rupestris Lep., Apis mellifica L.*

IV. Anatomical Part

HIND WING

The hind wing of Hymenoptera bears on its front margin two kinds of chitinous appendages, the clasping hooks and the marginal bristles, which, during flight, are in contact with the fore wing. Of the hooks two types, differing from each other morphologically, topographically, and in part also functionally, are to be distinguished. These have already been distinguished by Staveley as distal hooks and subbasal hooks.

The distal hooks, which play the principal rôle in uniting the wings during flight, are located on the anterior margin of the hind wing, on the upper side of the costal vein. In the Tenthredinidæ and Uroceridæ they are arranged somewhat irregularly, often appearing to form a double row (pl. VII, fig. 3); in all the other families, when present in large numbers, a single row (pl. VII, figs. 1, 2, 5, 7-9; pl. VIII, figs. 10-13). This hook-row begins, as the figures show, before, at, or behind the place where the cross-vein branches from the costal vein, and extends not quite half way of the distance between this branching and the apex of the wing. This region of the wing is commonly indicated as the frenum; therefore, instead of the not very characterizing name "distal hooks," perhaps the term "frenal hooks" could be used for these appendages. The hooks of the Tenthredinidæ and Uroceridæ do not form two strictly parallel rows, but rather a row of hooks standing in groups of twos—in large forms, also in threes. The arrangement of the individual hooks of these groups is irregular and variable, not only in different species, but also within the same species. In the forms with a single row the distal hooks usually lie in a straight line parallel to the margin of the wing; sometimes, as in many Ichneumonids, they form a gentle curve open towards the anterior margin of the wing. The intervals between the individual hooks differ greatly. In the genera *Bombus* and *Xylocopa* they are very close together, comb-like, in contact with each other at the base; in the other Anthophilids and the remaining families they are 50 to 200 microns apart. The strongest and largest hooks generally stand farthest apart, so in the Vespids the first ones and in the Ichneumonids the middle ones, but no uniformity can be recognized in this respect. The number of the distal hooks in the different species varies exceedingly, from two (*Proctotrupes*) to about 50 (*Sirex*). Even among different individuals of the same species the number of hooks is very variable. This, as well as the availability of the number and arrangement of the hooks for systematic purposes, will be dealt with below in the systematic part.

The distal hooks have the shape of rather flat bands. Only at the base, and just above it, the cross-sections are circular (pl. X, fig. 31); towards the tip, they soon become elongated, elliptical. The shape of a distal hook can be readily made out by the aid of fig. 10 on plate VIII (surface view) and fig. 22 on plate IX (transverse section). The hook describes an arc, open towards the wing surface. This arc does not, however, extend in a plane, but describes half to three-quarters of a spiral, the axis of which is parallel to the costal vein. The basal portion of the hook is inclined towards the costal vein. With this it incloses an angle of 40 to 60 degrees and with the wing surface an angle of 90 to 120 degrees. When the latter approaches 120 degrees the central parts of the hooks project beyond the anterior margin of the wing, particularly when this margin is strongly turned down, as in the flower-wasps (pl. VII, figs. 7, 9; pl. VIII, figs. 11, 12, 13). The stouter hooks of the series are particularly strongly bent. The distance between their ends and the wing surface is less than the space taken up by the corresponding part of the groove of the fore wing (made clearer by lines in pl. IX, fig. 22). As the transverse sections (pl. IX, figs. 19-25), show, the hooks are uniformly curved and, however much twisted, never, as the surface view might lead one to assume, abruptly bent at any point. If a hook were straightened out, its form would be lanceolate. It is broadest in the middle and narrows towards the apex, finally tapering to a point. A tubular cavity extending the entire length of the hook is always clearly discernible. Conforming to the shape of the hook, this cavity, in transverse section, is circular or punctiform at the base (pl. x, figs. 31, 1), and shaped like a narrow slit farther up. It appears to terminate some distance below the apex. I have never been able to see an orifice at the end of a hook. This hook-cavity is, as a rule, in open connection with the cavity of the costal vein, but this communication may be interrupted by soft matrix or chitinous layers secondarily formed. Sometimes the walls of the costal vein itself are thickened to such an extent that its lumen is obliterated and the vein itself converted into a solid rod, from which it is to be inferred that these cavities generally are not of any importance. The costal vein is sometimes considerably broadened in the frenal region, sometimes throughout the whole hook region (pl. VII, fig. 6); sometimes it is dilated at the point of insertion of each hook (pl. VII, fig. 4). In most cases, however, it shows no distinct differentiation in the hook region except a slight incurving at the base of the hooks. The distal hooks are inserted in the upper surface of its wall, either in the middle of its broad face or nearer to the wing margin (pl. x, figs. 27-29). It is interesting that the Tenthredinids and Anthophilids, which are systematically very far removed from each other, also show the greatest differences in the mode of attachment of the hooks, while in the families systematically intermediate transitional forms of hook attachment are seen. The difference in the mode of insertion of the hooks appear to be correlated to the differences in the formation of the costal vein, and not solely dependent upon differences of habit. For the investigation of these conditions in the Tenthredinids I had at my disposal, besides *Tenthredo mesomelæna* L., abundant and excellent specimens of *Sirex gigas* L., an ideal material for this work on account of its large size. In both species I found the hooks quite similarly inserted. I will therefore describe them together. *Sirex gigas* is, like the other Tenthredinids, remarkable for the thinness of the wing-lamellæ and the spacious cavities in its wing veins. Its hooks are very much flattened, distinctly ribbon-shaped. The attachment of the hooks involves considerable modifications of the wall of the costal vein at the points of insertion. The hooks are inserted in circular openings of the vein wall, the margins of which are raised up to form elevated rings, both outside and in. The outer elevation is very slight (pl. x, figs. 27, 28, 29, R), while the inner one attains considerable dimensions. These elevated rings are not cylindrical, but form semiglobular pans (pl. x, figs. 27, 28, 29, P). In sections through the wings of fully developed specimens caught on the wing the cavity of the pan is not in connection with the lumen of the vein. In young, not fully colored specimens cut out of pine wood, I found the bottom of the pan perforated; but in the center in every case there was distinguishable a differentiated bordering layer between the pan-cavity and the matrix of the costal vein (pl. x, fig. 27, Gr). In older animals also the bottom of the pan sometimes appears centrally perforated in cross-section, but in this case the edges of the opening are sharply broken, and clearly indicate that the missing piece of the bottom has broken away in sectioning, on account of the well-known brittleness of older chitin (pl. x, fig. 28). This difference between young and fully developed specimens shows that the closing of the chitinous pan is effected by chitin secreted after the formation of the wing-lamellæ. The pan is about 37 microns wide. Its outer opening is covered, like a drum, by a fine membrane, which appears as a continuation of the outer layer of the upper wing lamella (pl. x, fig. 28, Me). Centrally this membrane incloses the hook, the basal part of which projects about 15 microns into the cavity of the pan. The hook has a diameter of 22 microns. It is not thickened at the base. The lumen of the hook (pl. x, fig. 28, I) terminates basally with a funnel-shaped extension. Numerous fine, transparent chitinous threads arising from the inner wall of the pan, attach themselves to the basal end of the hook (pl. x, fig. 28, F) and hold it fast. From the central portion of the bottom of the pan no such threads arise. This contributes to the ease with which this part of the pan is broken away in sectioning.

A type of insertion wholly different from this is found in the Anthophilids. In these Hymenoptera the wall of the costal vein is extremely thick. Sometimes the two lamellæ forming it, of which the upper is always considerably the thicker, touch each other, so that the vein lumen entirely disappears (pl. x, fig. 30). It is perhaps on account of the strength of the walls of the costal vein, that the mode of inserion of the hooks is much less complicated in the Anthophilids than in the Siricids. I particularly examined the distal clinching hooks, peculiar to the Anthophilids, in *Apis mellifica* L., *Bombus terrestris* Latr., *Bombus lapidarius* Walck., and *Megachile cricetorum* Lep. The upper lamella of the costal vein, very stout in all the species of this family, forms prominent ring-shaped thickenings round the bases of the distal hooks (pl. x, fig. 30, R), which are homologous with the elevated rings of the Tenthredinids. The prominences are centrally perforated by conical tubes into which the basal ends of the hooks are inserted. The considerably thickened basal end of each hook fits closely into this tube, so that the hooks appear firmly embedded in the costal vein (pl. x, fig. 30). The distal hooks of

Apis mellifica are at the point of insertion in the tube about 12 microns and at the basal end about 15 microns thick. The lumen of the hook, which in the Anthophilids possessing a hollow costal vein is in open communication with the lumen of the vein, does not terminate with a funnel-shaped extension; at the most, such an extension is only slightly indicated. This anthophorid type of hook insertion possesses the decided advantage of greater strength over the tenthredinid type, but this greater strength is gained at the expense of that elasticity and movability which is attained in the Tenthredinids through the attachment by means of the drum membrane and the chitin threads. The distal hook of a bee or bumblebee can only be removed from the wall of the costal vein, without being itself broken, by shattering the costal vein to which it is attached. As a result of this, during the upward stroke of the wings, the fore wing presses principally on the central parts of the hooks in the Anthophilids, while in the Tenthredinids this pressure is transmitted to the drum membranes covering the pans and the chitin threads attached to the bases of the hooks. In accordance with this, the distal hooks of the Anthophilids are considerably broader, longer, and thicker than the typically ribbon-shaped hooks of the Tenthredinidæ. Numerous transitional forms connect these extremes. The Anthophilidæ type is by far the most common, narrowness of the lumen of the costal vein, or even solidity of it, being the rule.

Besides the distal hooks, in many Hymenoptera another kind of hook occurs—Staveley's subbasal hooks. These are situated, as the name implies, near the base of the wing, and sometimes also halfway between this and the distal hooks (pl. VII, fig. 3, SbH; pl. VIII, figs. 14-18). They are not met with in all the families, and show great diversity in regard to number, arrangement, and development. In the Vespidæ, Formicidæ, Evaniidæ, and Proctotrupidæ they are wholly absent. In some Apids and Fossores they can be recognized as slightly curved, stump-like processes, placed midway between the basis of the wing and the distal hooks, generally nearer the latter. Many genera of these families, however, are entirely without them. It appears doubtful whether the chitinous structures of the Cynipidæ, Braconidæ, and Tenthredinidæ corresponding to the subbasal hooks of other families, should be designated as clasping organs, because they are hardly at all curved. Only in a single species of the last-named family, in *Pamphilius hypotrophicus* D. T., I discovered curved subbasal hooks. These are very peculiarly bent, about ten in number, and form a group near the base of the wing (pl. VIII, fig. 15). In *Sirex gigas* L. appendages are found in the same location, which partly resemble subbasal hooks and partly marginal bristles (pl. VIII, fig. 18). The Ichneumonidæ and Chrysididæ possess well developed, highly differentiated subbasal hooks. In the first these arise close to the base of the wing from the upper of the two branches into which the costal vein divides at its origin (pl. VIII, fig. 3; pl. VIII, fig. 16). In the Ichneumonidæ there is either only one subbasal hook or a group of hooks standing close together, while in the Chrysididæ, where always a considerable number of them is present, the hooks stand at greater and irregular intervals (pl. VIII, fig. 17). The subbasal hooks are directed obliquely towards the apex and outer side of the wing. With the costal vein they inclose an angle of about 50 to 80 degrees (pl. VIII, figs. 14-18), and with the wing surface, as the accompanying diagrammatic figure of a cross-section shows, an angle of about 140 to nearly 180 degrees. When this angle approaches 180 degrees these hooks lie almost wholly in the plane of the wing surface.

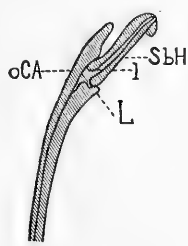


FIG. 20.

In their outward appearance the subbasal hooks differ from the costal hooks principally by their being less curved; only just below the distal end they are bent. Like the distal hooks, their transverse section is circular at the base, and narrow, elliptical distally. They arise from the upper side of the costal vein; or, when this is bifurcate, from its anterior branch, in the same manner as the distal hooks (pl. VIII, figs. 15, 16, 17, oCA). The anterior branch of the costal vein is, in the Ichneumonidæ, short and thickened in the region of the subbasal hooks. It is, as the sections show, often provided with an entirely isolated lumen. Like the distal hooks, the subbasal hooks possess a lumen, in transverse sections circular or punctiform at the base and slit-shaped distally. When the vein from which the hooks arise is hollow the hook cavity openly communicates with the vein cavity. Distally the hook cavity terminates below the pointed apex of the hook; its end is closed. The manner of insertion is the same as in the distal hooks. The points of insertions do not, however, lie central on the broad side of the costal vein, which is elliptical in cross-section, but greatly approximated to the margin of the wing; at times wholly marginal. (Compare the above diagram, fig. 20, of a cross-section through the wing of an ichneumon-wasp in the region of the subbasal hooks.)

Besides the distal and subbasal hooks, the anterior margin of the hind wing, as a rule, bears more or less strongly developed marginal bristles. In the Tenthredinidæ these are very poorly developed and sometimes wholly wanting; in the Ichneumonidæ and Chrysididæ they are well developed, and they are strongest and stoutest in the Vespidæ and Anthophilidæ (especially in Bombus). They usually stand in three dense, comb-like groups or rows, the first near the base of the wing (pl. VIII, fig. 16), the second before (pl. VII, figs. 1, 6 B 2, 9; pl. VIII, figs. 11, 12, 13), and the third beyond the distal hooks (pl. VII, figs. 1, 6 B 3, 9; pl. VIII, figs. 11, 12). These three groups are not always distinctly developed; the group before the distal hooks is the one most frequently observed and the most highly developed. The marginal bristles are not, like the hooks, restricted to the costal vein, but also attached to the parts of the wing membrane adjacent to the costal vein (pl. IX, fig. 26, B 2). Their direction is similar to that of the subbasal hooks; they inclose an angle of 90 to 180 degrees with the wing surface. These bristles are straight or slightly curved and twisted. In size they considerably exceed the subbasal hooks, attaining a length of 233 microns, while the subbasal hooks are at the most 57 microns long. They are inserted in low ringed ridges on the upper lamella of the wing and possess a narrow axial lumen distally closed. The chitinous spines which, in the Ichneumonidæ, Vespidæ, and Anthophilidæ, often accompany the series of hooks in the frenal region (pl. IX, figs. 20, 22, 23, Z 1), are also to be considered as marginal bristles of this kind.

FORE WING

The posterior margin of the fore wing is recurved and folded in, so as to form a groove. Into this groove the hooks of the hind wing are inserted (pl. IX, figs. 19-26, R i). In the Anthophilidæ, Fossores, and Vespidæ a convex bulging of the upper side of the wing is connected with this more or less highly developed plicature of its posterior margin (pl. IX, figs. 22-26). The plicature and the groove produced by it extend over the proximal half of the hind margin of the wing, and terminated distally at the place where the anal vein reaches the margin of the wing. Here the groove ends abruptly in a knob. Towards the wing basis this plicature flattens out. In forms possessing subbasal hooks closely approximated to the base of the wing the plicature (groove) is deeper at the place opposite these hooks, but there never is, as stated by Staveley (1860, p. 135), a second groove near the base of the wing separated from the distal one by a tract of unfolded wing margin. The plicated chitin forming the groove is much darker than that of other parts of the wing, and the parts of both the lamellæ composing the wing which form the groove are much thicker than the parts forming the wing proper (pl. IX, most plainly visible in figs. 22 and 23). From the upper convex side above the groove short, pointed, spines arise. These are particularly numerous near the margin. They correspond to the spines of a similar kind mentioned in the discussion of the hind wing, and, like these, are directed obliquely towards the apex of the wing (pl. IX, figs. 19 Z 2, 20). Therefore, as Staveley mentions (1860, p. 135), the margin of the groove appears serrate in surface views. Such spines are chiefly met with in the Tenthredinidæ and Ichneumonidæ. In the Vespidæ, most of the Fossores, and the Anthophilids these spines are less numerous, more blunt, and often absent altogether. On the other hand, most of the representatives of the last-named families possess a longitudinal ridge near the margin of the groove generally restricted to the frenal region (pl. IX, figs. 22, 23, Lg), which may be looked upon as a functional equivalent to the spines in other families.

DEVELOPMENT OF THE HOOKS AND THE GROOVES

In the autumn of 1905 I obtained some nests of *Vespa rufa* L., and their pupal inmates offered me an opportunity of investigating the development of the clasping organs, the structure of which has been described above. As unfortunately I did not succeed in obtaining an unbroken series of developmental stages and in this memoir an embryological chapter was not contemplated, I must restrict myself to describing the main features in the development of the distal hooks and the groove as observed by me. The development of the distal hooks commences simultaneously with the brown pigmentation of the eyes and the folding of the wings within the pupal envelope. It is initiated in the region of the frenum. First some hypodermal cells, lying in a row and belonging to this region of the costal vein, become considerably enlarged. In surface views these cells appear as a row of low, small elevations on the upper side of the costal vein. It is possible that the presence of larger fragments of fat body, which is always noticeable at this stage, is in some way connected with the formation of the hooks. The cells forming these elevations are the mother-cells of the hooks. From their upper side processes, resembling the necks of bottles, grow out and rise above the upper wing-lamella. These bend over arcuately, secrete a chitinous covering, and thus form the hooks. The formation of chitin is first consummated at the distal end of the hook; whereupon the tapering distal process of the mother-cell withdraws from the end of the hook. In the lumen of the fully formed hook no living substance (marrow of hypodermal matrix) is present. A regeneration of worn off hooks is therefore impossible. The cuticule of the upper wing-lamella, pierced by the hooks, sinks down around their basal ends, round which it is thickened and from which it is divided by an incision. (The depression is shown in fig. 33, the incision in fig. 32 on plate x.) On the whole the hooks are developed in the same manner as the hairs and scales of the Lepidoptera, the development of which has been described by Semper (1857, pp. 326-339). Like these unicellular structures which are fully chitinized in the developed animal, they are neither capable of secondary growth nor of regeneration.

The groove-like plicature of the posterior margin of the fore wing is formed rather late, about the time when the coloring of the body commences. The upper wing-lamella takes a more prominent part in the formation of the groove than the lower. This predominance of the upper over the lower lamella, clearly recognizable also in other respects, is particularly noticeable during development (pl. x, figs. 34, 35).

V. Function of the Clasping Apparatus

The connection established between the fore and hind wings by means of the hooks and groove is extremely close and energetically maintained. It is only with difficulty that the hind wings can be detached from the fore wings in the living animal without injuring the wings, and as soon as one lets go, the parted wings are immediately reunited by a powerful stroke. What functions pertain to the different parts of the clasping apparatus during flight and in what manner they are brought into play may be elucidated by a consideration of the wing-stroke. The position of the wings is, according to Marey (1869, p. 667), such that in the downward stroke the upper side of the wing faces obliquely forward; in the upward stroke, obliquely backward. At the same time the apex of the wing describes a line approaching the shape of the figure 8, with narrow upper loop (1872, p. 2).

The accompanying diagram shows approximately the position and direction of the two wings in the principal phases of a wing-stroke. It can be seen that, in the upward as well as in the downward stroke, the fore wing drags the hind wing after it, the latter as it were holding on to the groove of the former by means of the distal hooks. As the connection of the wings is not rigid, the hind wing forms an obtuse angle with the fore wing. Firmly clasping, stout, and strongly bent distal hooks and a deep and firm groove will be of great service in attaching the hind to the fore wing. At the points where the direction of the stroke changes, particularly at the apex of the eight, the upper loop of which, as Marey states (1872, p. 4), is usually very narrow, the wings will have the tendency to move in opposite directions and unclasp, as indicated by the small arrows in the figure. This tendency is restricted to but a moment, and probably not very strong. The wings are protected against the danger of unclasping at this point by the strong recurving of the tips of the distal hooks and strongly projecting margin of the groove (pl. IX, figs. 22, 23, are ideal examples); also the spines at the base of the hind wing and on the convex side of the groove of the fore wing may assist in the prevention of such unclasping, since, acting like rasps, they impede the relative slipping of the

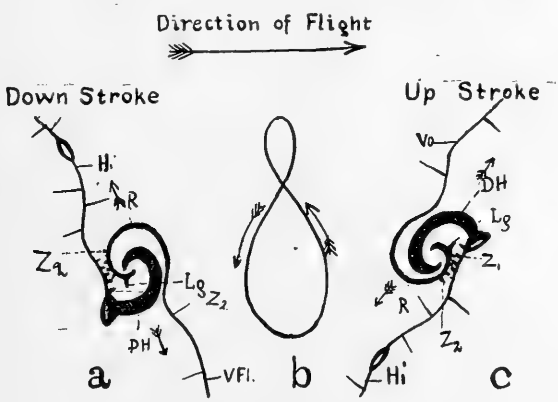
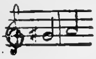
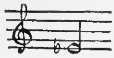


FIG. 21.

wings. The function of the subbasal hooks is the same as that of the distal hooks; they play, however, a subordinate rôle, and in many cases (particularly in the Tenthredinidæ) they pass over, morphologically as well as functionally, into the marginal bristles, which simply rest against the groove and thereby increase the elasticity of the connection. They are naturally most highly developed in forms with long wings and with the distal hooks greatly approximated to the apex of the wing, as in the Ichneumonidæ. The function of the distal hooks of the Tenthredinidæ, standing in several rows (pl. IX, fig. 19), is more difficult to explain. Those approximated to the wing margin are so strongly bent outward that the outer ones at least probably also get into the groove under certain circumstances. Their delicacy and elasticity probably enable them to do this (see above).

In reviewing the clasping arrangement in the Hymenoptera, two principal types, forming the two ends of a pretty continuous series of transitional forms, can be distinguished. The first of these types is found in the Tenthredinidæ, Ichneumonidæ, and Formicidæ; the second in the Anthophilidæ and Vespidæ. The Tenthredinidæ (pl. IX, fig. 19), Ichneumonidæ (pl. IX, fig. 20), and Formicidæ (pl. IX, fig. 21) have very flat, rather short, and only slightly bent hooks, at their bases delicate pointed spines (lacking in the Formicidæ), a widely open groove, furnished with slender spines on the outside (also lacking in the Formicidæ), no longitudinal ridge, and (as a rule wanting in the Tenthredinidæ) generally sparse, short marginal bristles. The clasping apparatus of the Tenthredinidæ is elastic and not very firm; in the Ichneumonidæ and Formicidæ it corresponds to the type described in the Anthophilids, but, in consequence of the thinness of the wall of the costal vein, it lacks the firmness peculiar to this family. Characteristic for the Anthophilidæ and Vespidæ (pl. IX, figs. 22-26) is the presence of well-developed, firm, long, and well bent distal hooks, numerous, stout, blunt spines at the bases of the hooks, and usually a longitudinal ridge on the outer side of the always deep groove, as well as long marginal bristles standing in closely crowded groups. Here the clasping apparatus is remarkably firm. On the whole, the clasping apparatus of the Anthophilids and Vespidæ is firmer than that of the Tenthredinidæ, Ichneumonidæ, and Formacidæ. and the question arises whether a correspondingly higher demand is made upon it in the former than in the latter families. The resistance of the air to the firmly joined wings principally depends upon the rapidity of the movement of the wings, *i. e.*, the number of wing-strokes executed per second and the length of the wings. According to the investigations of Marey (1886, p. 126), the bumblebee makes 240, the bee 190, the wasp 110 wing-strokes per second. No such data are available for the Tenthredinidæ, Ichneumonidæ, and Formicidæ. It is, however, possible to judge of the number of wing-strokes by the pitch of the tone produced by them in flight. Of course, no absolute data can be obtained in this manner, for errors will always creep in, caused, in accordance with Doppler's principle, by the raising of the tone when the insect approaches and its lowering when it retreats, the mingling of the tone of flight with the voice proper, etc. But these errors are not such as to preclude the possibility of deducing approximately the differences of the number of wing-strokes per second from the differences in the pitch of the tone, and it is only this that is essential here. The pitch of the wing-tone in flight is given by Landois (1867, p. 69) for *Apis* ; for *Bombus terrestris,* small male, ; for a larger male of the same species ; and for a large female of *Bombus muscorum,* . I have determined the wing-tone of *Sirex gigas* and *Rhyssa persuasoria* as . In many Ichneumonidæ, and in all Formicidæ no measurable tone of flight can be heard. These great differences in the pitch of the tone of flight of the Anthophilids and Vespidæ on the one hand and the Tenthredinidæ, Ichneumonidæ, and Formicidæ on the other, doubtless confirm the conclusion, forced upon one by a comparison of the structure of their flying organs, that the latter move the wings more slowly than the former. This difference in the rapidity of wing-movement evidently has its cause in the difference of proportion of the wing-area to the weight of the body: the Anthophilidæ and Vespidæ possess relatively much smaller wings than the Tenthredinidæ, Ichneumonidæ, and Formicidæ. If the wings of *Sirex gigas* are compared with those of *Vespa crabo,* the fore wing alone of the *Sirex* will be found to cover both wings of the larger and stouter hornet. Rapid and precise flight is probably only possible for those Hymenoptera which have firmly united fore and hind wings. Experiments made to prove this would be of doubtful value, since the removal of the hooks or the groove mutilates the wings to such an extent that it would be impossible to judge what part of the resulting peculiarities of flight should be attributed to the loss of the clasping apparatus and what part to other causes. I have several times observed bumblebees remarkable for their laborious, aimless, and wavering flight; a close examination of such always showed the hooks much injured, probably by wear.

VI. Systematic Part

The idea readily suggests itself to utilize the arrangement, number, and development of the hooks of the hind wing for systematic purposes. The first attempt in this direction, which was also the last, was made by Staveley, who ascribed a considerable systematic value to the hooks. André, who, however, otherwise does not approach the subject more closely, is very skeptical in this respect (1882, p. 65). Staveley has published a key, which, based upon the morphology of the costal vein of the hind wing and the arrangement of the distal hooks, gives in the main the following arrangement:

I.—Costal vein divided at the base.

A.—Upper branch of the costal vein marginal, reaching to the middle of the wing, where it again unites with the lower one.

Subdivisions are distinguished according to the following principles:

Cross-vein branches from the costal vein at or behind the point of junction of the two branches of the costal vein.

Series of distal hooks beginning before, at, or behind this point of junction.

B.—Upper branch of the costal vein marginal, after a short space becoming very thin or disappearing altogether. The lower branch reaches the wing-margin behind the middle.

Subdivisions according to the following principles:

End of the upper branch of the costal vein distinct or indistinct.

Wing-membrane outside the costal vein in the region of the distal hooks visible or invisible.

II.—Costal vein not divided at the base; simple; behind the middle of the wing not marginal.

Subdivisions according to the following principles:

Cross-vein branching from the costal vein behind the middle;

Series of distal hooks begins before or at this branch.

III.—Costal vein not divided at the base; marginal; unites behind the middle of the wing with the II longitudinal vein.

A.—The two veins, after their junction, continue as one.

Series of distal hooks begins before this junction.

Subdivisions according to the following principles:

Series of hooks single or double.

B.—Costal and II longitudinal vein forming a loop by again dividing after their junction and thereupon again uniting.

Series of hooks always double.

To ascertain the family to which an undetermined Hymenopteron belongs, the table of Staveley is not suitable. The reasons for this are the following: Only a few families are restricted to one division (Vespidæ, I. A; Ichneumonidæ, I. B; Apidæ, Formicidæ, II); many families and even subfamilies are distributed over several divisions; so the Sphegidæ over I. A and I. B, the Tenthredinidæ over II., III. A, and III. B, etc. Furthermore, in some of the divisions representatives of the most heterogeneous families are united, *e. g.*, II. Apidæ, Crabronidæ, and Tenthredinidæ. Finally the number of species indicated as examined by Staveley is exceedingly small. Cynipidæ and Braconidæ are not mentioned by her at all. Moreover, no necessity exists for the use of the differences in the arrangement of the hooks, spines, etc., other much more conveniently examined characters, as the wing-venation, the structure of the legs and antennæ, etc., being amply sufficient for the determination of the families. Nor can peculiarities of the clasping arrangement be used for differentiating nearly related genera similar in their grosser characters, because such nearly always agree in the character of their clasping organs. Neither does the structure of the clasping apparatus admit of the recognition of the different sexes of the same species, males and females showing the greatest similarity in this respect. At the most, the larger females possess more hooks than the smaller males (*Bombus, Camponotus, Vespa*). The number of the hooks, of the distal as well as the subbasal rows, is by no means constant and characteristic for any one species, but varies more or less with the size of the animal, between very wide limits. Of a number of species it may be said that the number of the hooks is primarily in accordance with the size and not with the power of flight. The great variability in the number of hooks, which precludes their utilization in systematic work, may be shown by the following table, in which the results of counting the number of hooks in different specimens of three species are brought together (*l.*—left; *r.*—right wing):

Sirex gigas L.		*Rhyssa persuasoria L.*				*Vespa rufa L.*	
l.	*r.*	*l.*		*r.*		*l.*	*r.*
37	30	SbH.	D H.	SbH.	D H.	20	19
37	49	1	11	1	11	24	28
38	37	1	12	1	13	24	29
39	41	1	13	1	13	26	27
39	42	1	14	1	15	26	28
43	39	1	15	1	15	28	28
43	43	1	16	1	13	27	27
43	45	2	16	2	17	27	29
45	43					28	27
46	43					29	28
46	49					29	29
48	50					29	29
50	47					29	32
51	53					31	32
52	46						

(All the specimens of *Vespa rufa* were taken from the same nest.)

This table shows how wide the limits of variation are in this respect, even in a comparatively small number of individuals of the same species. It also shows that usually even the same individual has different numbers of hooks on the right and the left hind wing. A repetition of the same numbers in different specimens turns out to be still more rare, and was only found once in *Vespa rufa*

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(29–29). The figures given prove better than a long discussion could, that the study of the number of hooks, however promising it may be to the biometrician, is of no use to the systematist.

Although it can only be conceded a very problematic value as an aid in determination, it can still be used, in most cases, as a contribution to the general characterization of the species, genera, and, with certain restrictions, also of the families, among which the Cynipidæ, Braconidæ, and the greater part the Ichneumonidæ show a pretty uniform development of the clasping organ. In so far as a characterization of this kind is possible, it is briefly offered below for the families, representatives of which I was able to examine.

I. Tenthredinidæ

The distal hooks are slender, slightly curved, typically ribbon-shaped, and very elastic. As a rule, they are arranged in double rows (pl. VII, fig. 4), placed upon the upper branch of the loop formed by the costal and subcostal vein and beginning before it. Single rows are very rare. Subbasal hooks are not always present; when developed they are generally not sharply distinguished (pl. VIII, fig. 18), only rarely well differentiated (pl. VIII, fig. 15). Marginal bristles are absent or very poorly developed.

Twenty species were examined, among them *Sirex gigas, Tenthredo mesomelæna* L., *Tenthredopsis thomsoni* in a large number of specimens.

II. Cynipidæ

The distal hooks are slender, very slightly curved, present in small number, and arranged very characteristically on the broadened end of the costal vein, where this reaches the margin (pl. VII, fig. 5). Subbasal hooks and marginal bristles cannot be distinguished from each other. They are present in very small numbers, and not well developed.

Three species were examined.

III. Ichneumonidæ

The distal hooks are long, slender, moderately curved, and placed upon the costal vein in a single row (as in all following), always beginning behind the junction of the cross-vein (pl. VII, figs. 3, 6).

Differentiated subbasal hooks, abruptly bent at the point, are always present. They are placed near the base of the wing, upon the upper branch of the forked costal vein, which branch disappears after a short course (pl. VIII, fig. 16). When present in greater number they stand at small, equal intervals. More or less robust marginal bristles are always present.

Thirty-four species were examined, among them in greater numbers *Pimpla instigator* Grav., *Rhyssa persuasoria* Grav., *Ichneumon fusorius* and *luctatorius* L.

IV. Braconidæ

The distal hooks are weak, slender, very slightly curved, and placed upon the costal vein a little behind the place where it joins the margin (pl. vii, fig. 8). The subbasal hooks are difficult to distinguish from the marginal bristles, which are more numerous than in the Cynipidæ.

Three species were examined.

V. Proctotrupidæ

Two extremely slender, very slightly curved distal hooks are present. These are placed in the middle of the anterior margin of the hind wing, in which, only at the base, an indication of a costal vein can be detected (pl. vii, fig. 2). There are sparse marginal bristles, but no subbasal hooks.

One species was examined.

VI. Chrysididæ

The distal hooks are well developed, generally very numerous, and placed upon the costal vein behind the insertion of the cross-vein.

Subbasal hooks are always present. They are well developed and placed at irregular intervals near the base of the wing (pl. viii, fig. 17). Marginal bristles are always present before and behind the series of subbasal hooks; they are stoutest at the base of the wing.

Three species were examined.

VII. Formicidæ

The distal hooks are very slender, delicate, and slightly curved. They are placed upon the costal vein, the series beginning behind the insertion of the cross-vein (pl. vii, fig. 7). Subbasal hooks are wanting. The marginal bristles are extremely small and thin.

Seven species were examined, among them, in a larger number of specimens, *Formica rufa* L., *Camponotus ligniperdus* Mayr., and *Lasius flavus* Mayr.

VIII. Fossores

In this family such a diversity prevails that it is hardly possible to give even an approximate characterization. The distal hooks, in form and arrangement, sometimes resemble those of the Ichneumonidæ, sometimes those of the Vespidæ, and sometimes those of the Anthophilidæ. The subbasal hooks are also very diversely developed, and sometimes absent altogether. The marginal bristles are not very well developed. It is remarkable that in this family they are often found in the middle of the series of distal hooks.

Twenty-two species were examined.

IX. Vespidæ

The distal hooks are very stout, strongly curved, and numerous. The series begins before or at the point of insertion of the costal vein (pl. VII, fig. 9). Subbasal hooks are absent. The marginal bristles are always numerous and well developed.

Nine species were examined, among them a larger number of specimens of *Vespa germanica* Fabr., *Vespa vulgaris,* and *Vespa rufa* L.

X. Anthophilidæ

The distal hooks are always stout, strongly curved, and numerous. The series begins before, at, or behind the insertion of the cross-vein (pl. VII, fig. 1; pl. VIII, figs. 11, 12, 13). The subbasal hooks, wanting in many forms, when present, short, stumpy, very slightly bent, and placed at irregular intervals between the base of the wing and the series of distal hooks (pl. VIII, fig. 13). Strongly developed marginal bristles are always present.

Eighteen species were examined, among them a larger number of specimens of *Bombus terrestis, hortorum,* and *lapidarius* L., *Psithyrus rupestris* Lep., and *Apis mellifica* L.

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VIII. EXPLANATION OF PLATES

All figures are photomicrographs, prepared with a Leitz microscope and a Zeiss microphotographic apparatus. Figs. 1 and 3 are taken with a Zeiss microplanar; all the others, according to magnification, with the Leitz objectives 3, 5, 8, without eye piece, partly by Welsbach light and partly by daylight.

The following abbreviations apply to all figures:

B 1, B 2, B 3.....Marginal bristles.
D H.............Costal vein; oC A, upper; u C A, lower branch.
C A.............Distal hooks.
F ....Chitinous threads.
Gr ....Border layer between wing-matrix and lumen of the hook.
Hi ....Hind wing.
L ....Lumen of the costal vein.
l ....Longitudinal ridge of the groove of the fore wing.
Ma ....Matrix of the costal vein.
Me ....Drum-membrane of the "pan."
oL ....Upper wing-lamella.
P ....Pan.
R .... Annular ridge.
Ri ....Groove of the fore wing.
SbH ....Subbasal hooks.
uL ....Lower wing-lamella.
Vo ....Fore wing.
Z 1..............Tubercles at the anterior margin of the hind wing.
Z 2............. Tubercles on the outer side of the groove.

PLATE VII

FIGURES 1-9.

All the figures are surface views.

1.	Hind wing of *Bombus terrestris* L.	Magnified	9
2.	Distal hooks of *Proctotrupes gravidator* L.	"	56
3.	Hind wing of *Rhyssa persuasoria* L.	"	9
4.	Distal hooks of *Tenthredopsis thomsini* Knw.	"	50
5.	Distal hooks of *Dryophanta folii* Forst.	"	130
6.	Distal hooks of *Anomalon flavifrons* D. T.	"	50
7.	Distal hooks of *Lasius flavus* Mayr	"	56
8.	Distal hooks of *Dacnusa petiolata* Hal	"	85
9.	Distal hooks of *Vespa vulgaris* L.	"	50

PLATE VIII

FIGURES 10-18

All the figures are surface views.

10.	Distal hooks of *Polistes galleca* Latr	Magnified	58
11.	Distal hooks of *Eucera longicornis* Scop	"	45
12.	Distal hooks of *Anthrena ovina* Klug	"	40
13.	Distal hooks of *Halictus calceatus* D. T. shows the peculiar arrangement of the distal hooks in groups.	"	70
14.	Subbasal hooks of *Halictus levigatus* Lep	"	70
15.	Subbasal hooks of *Pamphilius hypertrophicus* D. T.	"	70
16.	Subbasal hooks of *Henicospilus ramidulus* Steph	"	70
17.	Subbasal hooks of *Holopyga amoenula* Dahlb	"	75
18.	Subbasal hooks of *Sirex gigas* L.	"	35

PLATE IX

FIGURES 19-26

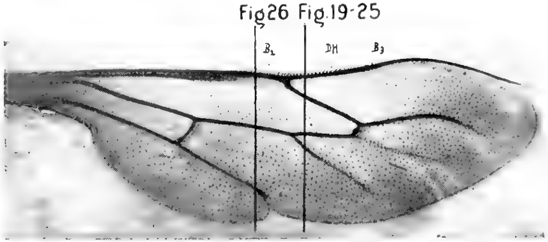
All the figures represent cross-sections through the two wings joined together. The region of the sections is approximately indicated in pl. VII, fig. 1, by vertical lines.

19.	*Sirex gigas* L.	Magnified	50
20.	*Exetastes fornicator* Grav	"	75
21.	*Formica rufa* L.	"	140
22.	*Vespa vulgaris* L.	"	130
23.	*Vespa crabro* L.	"	75
24.	*Apis mellifica* L.	"	140
25.	*Xylocopa violacea* Pr	"	45
26.	*Vespa vulgaris* L.	"	135

PLATE X

FIGURES 27-35

27. Cross-section through the costal vein at the place of insertion of the distal hooks of a young *Sirex gigas* L.	Magnified	280
28, 29. The same section of an older specimen of the same species	"	300
30. The same cross-section of *Apis mellifica* L.	"	300
31. Pazatangential section, through the costal vein of *Sirex gigas* L., seen from above	"	140
32. Cross-section through the costal vein at the place of insertion of the distal hooks of a young *Vespa vulgaris*	"	300
33. The same section of a pupa of *Vespa rufa* L.	"	300
34. Cross-section through the posterior margin of the fore wing of *Vespa rufa* L.	"	300
35. The same section of a young imago of *Sirex gigas* L.	"	300



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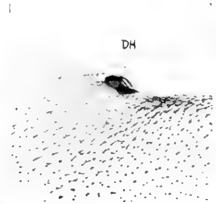

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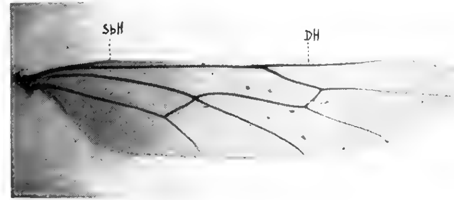

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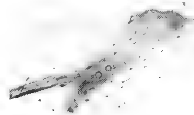

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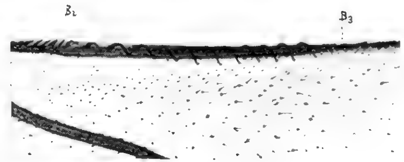

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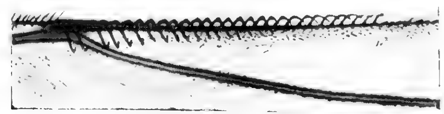

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WINGS OF HYMENOPTERA


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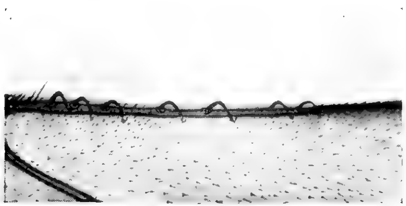
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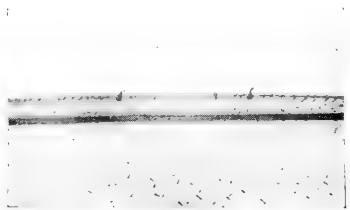
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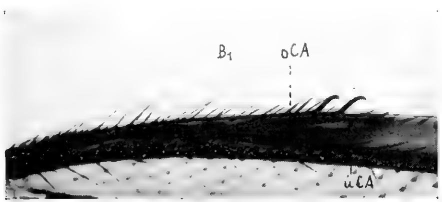

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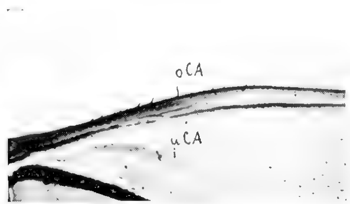

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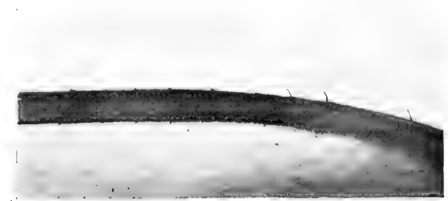
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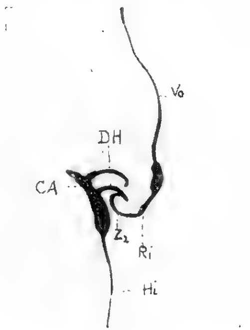
WINGS OF HYMENOPTERA



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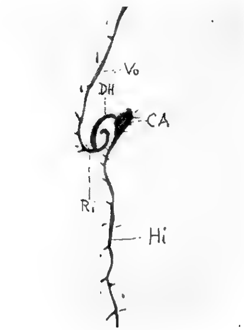

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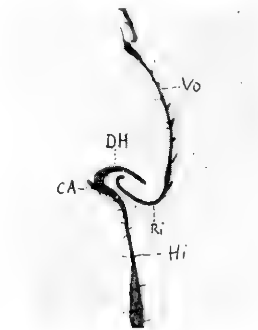

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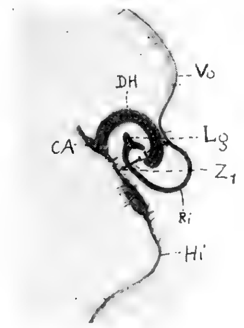

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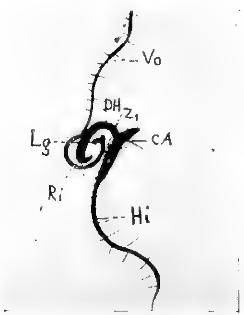

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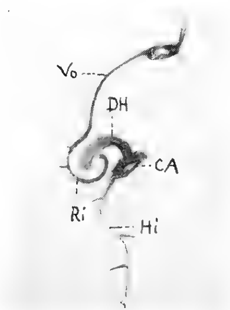

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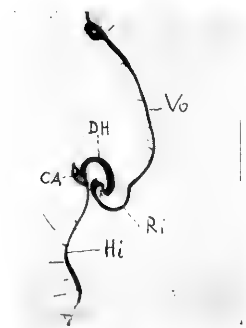

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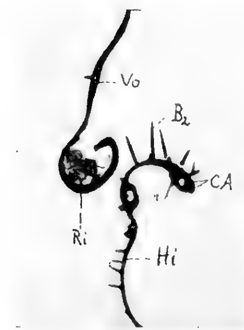

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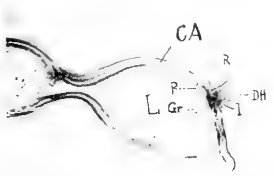
WINGS OF HYMENOPTERA



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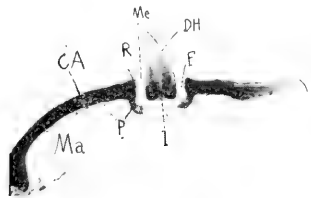

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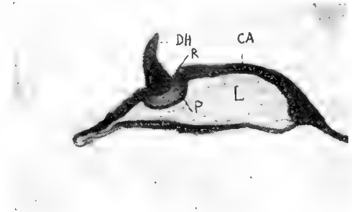

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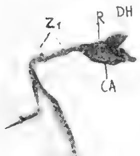

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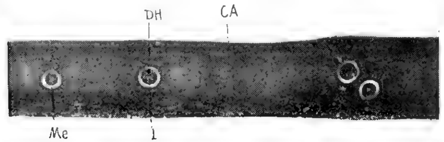

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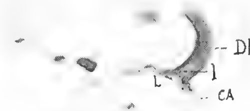

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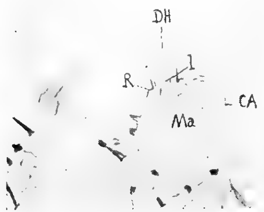

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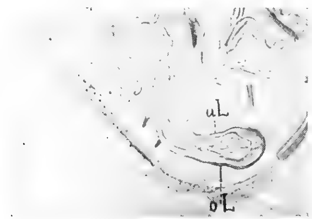

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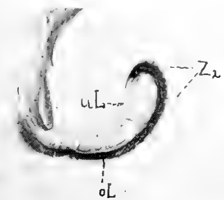

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WINGS OF HYMENOPTERA

NOTES ON MAMMALS COLLECTED AT MT. RAINIER, WASHINGTON

By MARCUS WARD LYON, Jr.

Assistant Curator, Division of Mammals, U. S. National Museum

In the summer of 1905 it was my good fortune to accompany the Mazamas[1] to Mt. Rainier, Washington, on their annual excursion, and through the kindness of the outing committee an outfit for collecting small mammals was carried with the regular baggage by pack train to the permanent camp, where I collected for the U. S. National Museum the specimens mentioned below.[2] This camp was located near timber-line, on the south side of the mountain, in Paradise Park, at an elevation of about 5,500 feet.[3] A few specimens were secured at Longmire Springs, 2,800 feet altitude.

MARMOTA CALIGATA (Eschscholtz)

Hoary Marmot

One specimen, an adult female, captured above camp, near snow limit. This species was fairly common in colonies in Paradise Park. They were unusually tame, as a rule, often permitting photographers to approach within a few feet, and could usually be called out of their rocky dens by whistling shrilly. It is commonly called "whistling marmot," or simply "whistler," in distinction to "marmot," a term popularly applied to the mountain beavers, *Aplodontia.*

EUTAMIAS COOPERI (Baird)

Chipmunk

1855 *Tamias cooperi* Baird, Proc. Acad. Nat. Sci. Philadelphia, vii, p. 334. (Committee reported in favor of publication April 24, 1855.)
1857 *Tamias townsendii* Baird, Mammals of North America, p. 330.

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[1] Mazamas, a mountain-climbing club of the Northwest, with headquarters at Portland, Oregon.

[2] For an excellent account of the larger mammals of Mt. Rainier, see Alden Sampson, *Sierra Club Bulletin,* vol. vi, pp. 32–38, January, 1906.

[3] For an account of this outing and description of this portion of Mt. Rainier, see *Mazama,* vol. ii, December, 1905, and *Sierra Club Bulletin,* vol. vi, January, 1906.

1890 *Tamias townsendii* ALLEN, Bull. Amer. Mus. Nat. Hist., III, p. 72, May, 1890.

1897 *Eutamias townsendi* MERRIAM, Proc. Biol. Soc. Washington, XI, p. 192, July 1, 1897.

As indicated by the above citations, *Eutamias cooperi* has for the past 50 years been considered identical with *Eutamias townsendii*. A comparison of the five specimens taken at 5,500 feet altitude, in Paradise Park, with the only existing cotype of *Tamias cooperi* Baird, taken at 4,500 feet altitude, Klickitat Pass, Cascade Mountains, Skamania County, Washington,[1] and with specimens of *Eutamias townsendii* collected only a few weeks earlier at Portland, Oregon,[2] makes it evident that two forms of *Eutamias* occur in the Pacific northwest, one, *E. townsendii*, probably occupying the Humid Transition area and the other, *E. cooperi*, the Hudsonian and Canadian areas.[3]

Eutamias cooperi is a lighter colored and grayer animal than *E. townsendii*; the light dorsal stripes, especially the outer ones, are distinctly gray, instead of wood-brown; the rump is also grayer and lacks the reddish cast seen in *E. townsendii*. The skulls of *E. cooperi* have the rostrum a little more slender than those of *E. townsendii*. In many ways *E. cooperi* appears intermediate in characters between *E. townsendii* and *E. quadrimaculatus*. The unusual grayness of Cooper's specimens was pointed out by Allen (*loc. cit.*), who, with the limited material at hand, did not consider it more than individual variation.

Concerning the exact locality of the cotypes of *Tamias cooperi* Baird, there seems to have been considerable confusion. The two cotypes are Cat. Nos. 211 and 212, U. S. N. M., and of these the first can not be found. The original label on Cat. No. 212 is simply marked "W[ashington] T[erritory]." In the first account of the species the locality is given as Cascade Mountains at 46°; but in Baird's Mammals (table, page 303) the locality for Cat. No. 212 is said to be "Vancouver, Oregon T." In Coues and Allen's Monographs of North America Rodentia (table, page 809) the locality for Cat. No. 212 is "Fort Steilacoom, Washington T." The collector of the specimens, however, clears up the matter of locality by a hith-

[1] See Cooper, in *American Naturalist*, vol. II, p. 531.

[2] These specimens may be regarded as topotypes, *E. townsendii* being originally described from the lower Columbia River.

[3] See Piper, *Contr. Nat. Herb.*, vol. XI, Map, Floral Areas of the State of Washington.

erto-overlooked note in the *American Naturalist* (II, 1869, p. 531), where it is given as Klickitat Pass, Cascade Mountains, 4,500 feet.

APLODONTIA MAJOR RAINIERI Merriam

MOUNTAIN BEAVER

Two specimens, not fully adult, from Paradise Park. Judging by the numerous holes and tunnels in the hillsides, this is a common species, although none were seen but the two individuals taken in steel traps placed in their burrows. The burrows or tunnels are about 8 to 9 inches in diameter and were always found in groups or colonies. Near their openings on the surface were often seen little piles of cut sticks and pieces of green herbage. The stomachs of the two individuals secured were distended with soft green vegtation. Locally this species is often called "marmot" and sometimes "high-ground muskrat."

PEROMYSCUS OREAS Bangs

WHITE-FOOTED MOUSE

Common in the dense woods at Longmire Springs, but much less abundant about the permanent camp in Paradise Park. Twenty-five specimens secured.

EVOTOMYS GAPPERI SATURATUS Rhoads

RED-BACKED MOUSE

The most common of the small mammals in Paradise Park, where 20 individuals were collected. None were taken at Longmire Springs. They were found indifferently in wooded or in open and bush-covered ground.

MICROTUS ARVICOLOIDES (Rhoads)

MEADOW-MOUSE

Six specimens from Paradise Park.

PHENACOMYS OROPHILUS Merriam

FALSE MEADOW-MOUSE

Four specimens from Paradise Park. This and the two preceding species made numerous burrows and runways about boulders and in banks in the park.

ZAPUS TRINOTATUS Rhoads

JUMPING-MOUSE

One specimen taken in the woods at Longmire Springs, and eight in the woods or open ground at Paradise Park.

SOREX OBSCURUS Merriam

DUSKY SHREW

Two specimens from Longmire Springs. None could be found at Paradise Park, although traps were set in likely places for them.

THE ARCHAIC MONETARY TERMS OF THE UNITED STATES

By CHARLES A. WHITE

As was customary with all English colonies, those of North America which became the thirteen original States of the Union adopted and used the monetary system of the mother country until it was superseded by our national decimal system; therefore all their monetary transactions were expressed and recorded in terms of pounds, shillings, and pence. That custom existed until our present national monetary system was established by Congress, in 1792–'93, eight years after the close of the War of the Revolution and three years after the final adoption of the Constitution of the United States, in 1789; that is, the people of the United States used the English monetary system not only during the whole of their colonial period, but during sixteen years, or fully one-eighth of their national existence up to the present time (1907), counting from the Declaration of Independence, in 1776. It is therefore not strange that its terms, or modifications of them, should still linger in colloquial speech. It is because some of those terms are now practically obsolete, and those which still survive are now only colloquially and locally used, that I have decided to make a record of them in accordance with my personal recollections, which began in the fourth decade of the last century, my personal observations in all the principal parts of the United States, and with available historical data.

The following table exhibits the monetary system of the United States as it was originally established and since modified by adding and eliminating certain coins; that is, its list of coins includes those which were originally designated by law, those which were afterward authorized, and those the coinage of which has been discontinued. The table is introduced for comparison of its coins with those of the other currencies which formerly have been used by our people.

From time to time other than the stated coins of the following table have been issued from the United States mints, such as the Trade dollar, souvenir gold and silver coins for the great expositions, etc.; but those coins bore special legends and, although officially recognized as money, they were not established portions of our coinage.

Various coins also have been issued by private parties, especially by gold-mining firms and corporations, to meet local monetary needs; but those coins, although of genuine intrinsic value and freely current in the regions of their origin, were not legally recognized as money and soon went entirely out of use as such.

THE MONETARY SYSTEM OF THE UNITED STATES

Denominations.	Divisions and multiples.	Metals.	Values.
The mill	Constructive unit	No coin.	$0.001
The cent	*d o.* Half-cent	Copper	0.005
	d o. One cent (large)	Copper	0.01
	A. One cent (small)	Copper	0.01
	d A. One cent	Nickel-copper.	0.01
	d A. Two cents	Copper	0.02
	d A. Three cents	Nickel	0.03
	d A. Three cents	Silver	0.03
	d A. Twenty cents	Silver	0 20
The dime	*d o.* Half-dime	Silver	0.05
	A. Half-dime	Nickel	0.05
	o. Dime	Silver	0.10
The dollar	*o.* Quarter dollar	Silver	0.25
	o. Half-dollar	Silver	0.50
	o. Dollar	Silver	1.00
	d A. Dollar	Gold	1.00
The eagle	*o.* Quarter eagle	Gold	2.50
	o. Half-eagle	Gold	5.00
	o. Eagle	Gold	10.00
	A. Double eagle	Gold	20.00

o. Originally designated by law.
A. Added by law to the original list.
d. Coinage now discontinued.

Originally the idea seems to have prevailed that only copper, silver, and gold were suitable for coinage, but nickel was introduced into our system after its original establishment. For a time that metal was used in varying proportions for coins of several small values, but it is now used only for the half-dime, which has come to be called specifically the nickel. Originally also the idea seems to have prevailed that definite ratios of intrinsic value naturally existed between copper, silver, and gold. The difference in size and palpable weight between the gold and silver coins of equal value and between silver coins and the large copper cent were generally accepted by the people as object lessons on the subject of those ratios. The assumed ratio between copper and silver, however, was summarily repudiated by the official suppression of the coinage of the large copper cent and the issue in the place of it of the smaller one of the same nominal value. The ratio of value between silver and gold is still an open question, and at one time it became a violent political issue. In designating the metal of each of the coins of the foregoing table, only the principal metal of each is mentioned, no reference being made to the alloys.

The denominations pertaining to our monetary system are, as the

FIG. 22.—Pine-tree shilling. Coined in Massachusetts in 1652.

foregoing table shows, mills, cents, dimes, dollars, and eagles; but only two of them are used in practical monetary annotation, namely, dollars and cents. The dollar being officially designated as the monetary unit, the other three terms are merely nominal portions of the formulated system, of which formula the mill is the constructive unit. The English monetary system consisted of four denominations, namely, farthings, pence, shillings, and pounds, four farthings constituting a penny, twelve pence a shilling, and twenty

FIG. 23.—Lord Baltimore shilling. Coined in Maryland in 1659.

shillings a pound. The commercial exchange value of the pound is about $4.85; of the shilling, 24 cents; and of the penny, 2 cents. Because Spain for more than one hundred years controlled the silver supply of the world and from her mints supplied the colonies, and afterward our newly formed States, with the greater part of their current silver coins, reference to their denominations is also necessary. These were the peso, which was equal in value to our dollar, the half peso, the quarter peso, the real, and the medio, the value of the two latter coins being 12½ and 6¼ cents respectively. It will be necessary further on to make frequent reference to the English and Spanish systems, because it was in connection with the coins of those two systems and with colonial bills of credit that there arose the now obsolescent terms which are about to be discussed. Those terms are the shilling, penny, levy, fip, bit, and picayune.

The monetary conditions which prevailed in the colonies and continued until after the War of the Revolution were extremely

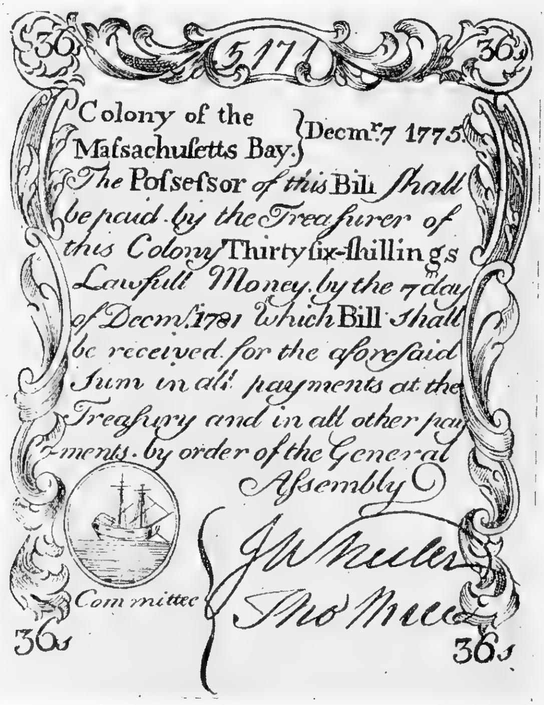

FIG. 24.—Massachusetts bill of credit for 36 shillings.

complicated and of uncertain availability for their trade requirements. Although the colonies had fully adopted the English monetary system, comparatively little English money seems to have found its way into their channels of trade. Each colony then claimed, and a part of them somewhat freely exercised, the right to coin money, and the few of those old colonial coins that have been saved from destruction are among the treasures of numismatists. All of the colonies also claimed, and most, if not all, exercised, the right to issue bills of credit. This right continued to be claimed by the States until it was prohibited by the Constitution of the United States as that instrument was finally ratified and adopted in 1789. States, counties, and municipalities have of course continued to issue bonds to meet legitimate indebtedness; but those bills of credit were not bonds of that kind. They were issued in terms of pounds, shillings, and pence for use as a form of paper money, and they actually were for a time a part of the common currency. Being a form of current money, it was necessary to recall them when the Constitution was adopted, and to provide for their payment in money of the then newly established national currency.

The long War of the Revolution and the consequent depressed condition of trade made it impracticable for any of the States which

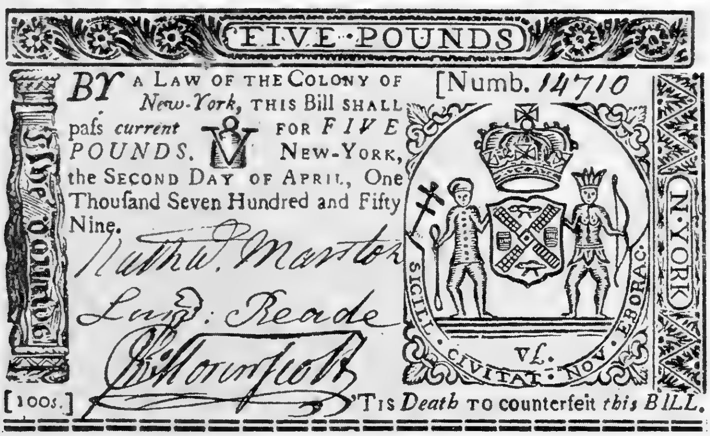

FIG. 25.—New York bill of credit for five pounds.

had issued bills of credit to pay them at their face value. By acts of their legislatures, Massachusetts and other New England States fixed the redemption value of their bills of credit at $3.33 to the pound sterling, making the shilling worth 16⅔ cents. Virginia, by legislative act, fixed the same value upon its bills of credit, and that act affected the Kentuckian and other settlements westward from Virginia, because that State then claimed jurisdiction over them. New York, for its own State limits, and by its influence over, and territorial claims within, the region westward, bordering the Great Lakes, by a similar act fixed the value of its bills of credit at $2.50 to the pound and the shilling at 12½ cents. North Carolina fixed the same rate. Pennsylvania, Delaware, Maryland, and New Jersey adjusted their bills of credit upon the basis of $2.70 to the pound and 13½ cents to the shilling. Georgia and South

Carolina made the best showing of all of them, fixing the value of the pound at $\$4.28\frac{4}{7}$ and that of the shilling at $21\frac{3}{7}$ cents. Let it be borne in mind that all of those legislative acts referred to American bills of credit and that none of them was aimed at English money as such, although they doubtless had an indirectly depressing effect upon the current value of that money which then remained in the United States.

With the establishment of the United States mint, the copper cent became comparatively plentiful, but the issue of other coins was for many years far less than the country needed. Besides this, the withdrawal of the bills of credit from circulation as money produced a financial condition which at that time would have been

FIG. 26.—New Jersey bill of credit for one shilling and sixpence.

disastrous had not large quantities of Spanish coins already been distributed throughout the country and in common use as currency. The bulk of that Spanish coinage was in quarter pesos, reals, and medios, the peso not having been very often seen in circulation; and the half peso was less common than were the smaller coins. Those Spanish silver coins remained in common use as currency nearly up to the beginning of the civil war.

It is a curious fact that, although the Spanish supply then constituted the principal part of our current coins, Spanish names for those coins were practically discarded by the people of the United States. The national term "dollar" was applied to the peso, and English or special terms were colloquially applied to its subdivisions.

FIG 27.—Peso = eight reals = piece of eight. Value, one dollar.

FIG. 28.—Half peso = four reals = four shillings in New York, four bits in the South and West, and three shillings in New England. Value, half a dollar.

FIG. 29.—Quarter peso = two reals = two shillings in New York = two bits in the South and West = one shilling and sixpence in New England. Value, quarter of a dollar.

FIG. 30.—Real = one shilling in New York = ninepence in New England = levy in the eastern middle States = bit in the South and West. Value, 12½ cents.

FIG. 31.—Medio = sixpence in New York = fo'pns hapny in New England = fip or fipnybit in the eastern middle States = picayune in the South and West. Value, 6¼ cents.

The value of the shilling as it was fixed for the New York bills of credit was exactly the same as that of the Spanish real, namely, 12½ cents. That Spanish coin therefore received the English name of shilling wherever the authority or uncontrolled influence of New York extended. The Spanish medio, or 6¼-cent piece, logically became the sixpence for that State; and even the American cent became the penny, although its value was a trifle less than one-twelfth of the New York shilling. Thus the people of that great commercial State used Spanish silver coins almost exclusively, but gave them English names that pertained to an officially discarded currency. Those New York monetary terms are still so often employed by the people of that State that few persons fail to understand them whenever they are used. Still they are not now nearly so commonly used as they formerly were, no doubt partly because the Spanish coins which they represented are no longer in circulation.

The following table concisely shows the manner in which English names were colloquially applied to Spanish coins in accordance with the New York provision for the retirement of the bills of credit. It should be compared with the next table, representing the New England provision.

NEW YORK ARCHAIC MONETARY TERMS

Current terms.	Current Spanish coins.	Value.
Sixpence	Medio	$0.06¼
Shilling	Real	0.12½
Two shillings	Two reals	0.25
Four shillings	Four reals	0.50
Six shillings	Six reals	0 75
Ten shillings	Ten reals	1.25
Twelve shillings	Twelve reals	1.50

The States of Pennsylvania, Delaware, Maryland, and New Jersey having fixed the value of the shilling in their bills of credit at 13½ cents, one cent more than New York gave it, the Spanish real was valued in those States at only eleven pence, the fraction of a cent being neglected in the estimate; therefore that coin came to be known there as the eleven-penny bit, which became abbreviated to "levy." The Spanish medio, or 6¼-cent piece, also neglecting the fractions of a cent, in like manner became the five-penny bit, which became abbreviated to "fipny bit," and still further abbreviated to "fip." The terms "levy" and "fip" seem not to have been customarily used in the plural form in the region where they originated, as were the terms "shilling" and "bit" in other regions. The use of those Pennsylvania and New Jersey terms did not extend northward, because the people of New York and New England adhered rigidly to their own local terms, but they extended to Delaware, Maryland, the District of Columbia, and Virginia. The people of the latter State seem to have practically disregarded the English monetary terms, which necessarily followed the act of their legislature in retiring the bills of credit and which were the same as the New England terms. Therefore, if one should now visit the rural districts of Pennsylvania and New Jersey and of the contiguous States southward, or the market places of their cities, he would occasionally hear at least the term "levy" still used. The term "fip," or "fipny bit," seems, however, to have gone entirely out of use in the regions where it originated, and to exist only in the memory of the older people.

The term "bit" as a partial designation of both the real and medio was evidently first used in the cases just mentioned with its ordinary meaning, equivalent to the word piece; but among the planters of the Southern States and the pioneers of the great Mississippi Valley it was the only term applied to the Spanish real. There also the terms "sixpence" and "fip" were not applied to the Spanish medio, but the créole term "picayune" was used instead. Those planters and pioneers affected to despise the cent as being a coin of too little value for consideration, and that sentiment is not entirely extinct in those regions where the term "bit" is still used. The American five-cent piece and the Spanish medio were the lowest coins they would consent to use, and they treated the two coins as of equal value, giving both of them the name of picayune. They gave the name bit also to the American ten-cent piece and for many years treated it as of equal value with the Spanish real.

That supercilious disregard for small values was taken advantage of by sharp traders. As the volume of coins issued by the United States mint increased, dimes and half-dimes made their appearance more frequently among the Spanish coins of the common currency. Those traders obtained supplies of dimes from the mint at the rate of ten to the dollar and paid them out at the rate of eight to the dollar, because they were accepted in common trade as bits of equal value with the Spanish real; but that enterprise soon came to an end by the necessary recognition of the respective coins at their true value, and the displacement of all Spanish coins from our national currency gradually followed. With that displacement the term "picayune" as a monetary designation went quickly out of use, but it has a curious survival in the name of the *New Orleans Picayune* newspaper, that name having been given to it to indicate its price per copy, which was then an unusually low one. The term "bit," however, continued in colloquial use, although no single coin remained in circulation to which it could be applied. Its application, therefore, was only to multiples of the bit value, the quarter-dollar being designated as two bits, the half-dollar, four bits, and three-quarters of a dollar, six bits.

The region in which the term "bit" has prevailed as a specific name for the Spanish real and for one-half of the quarter dollar may be designated as the States of the Great Mississippi drainage system and the contiguous States along the Gulf border. The emigration which crossed the Great Plains and the Rocky Mountains in the closing years of the fifth decade of the last century traversed that region and carried with it the term "bit" in its monetary sense to the Pacific coast. The result has been that, in the multiple form just mentioned, that term is now even more prevalent there than it is in any other part of our country.

The most remarkable case of the adaptive use of monetary terms in the United States which have become archaic, if not obsolete, is that which occurred in New England. It was there that the widest application of the terms of the English monetary system was made to American and Spanish values, and there also that those terms became dialectic in character. In Bristol county, Massachusetts, up to my thirteenth year, those terms were as familiar to me as household words, for my parents and all our neighbors habitually used them. My recollection of them is as distinct as is that of the terms "bit" and "picayune," which I also used in common with the people of the Mississippi valley for more than twenty years afterward.

The following table shows the archaic terms which were used in New England, and which resulted from the former use there of the English monetary system and the reduction of values of the bills of credit. The terms cent, half-dime, and dime are of course added to the table from our national coinage, but the remaining terms are locally characteristic. The latter were all in common use there during colonial time and also for nearly or quite fifty years after the establishment of our national mint. Now, however, they have gone entirely out of practical use.

NEW ENGLAND ARCHAIC MONETARY TERMS

Monetary terms.	Current coins.	Value.
Cent..	Large American copper coin.	One cent.
Half-dime	American silver coin	5 cents.
Dime	American silver coin	10 cents.
Four pence and half-penny	Spanish half-real or medio	6¼ cents.
Sixpence	No coin	8⅓ cents.*
Ninepence	Spanish real	12½ cents.
Shilling	No coin	16⅔ cents.*
One shilling and sixpence	American or Spanish coin	25 cents.
Two shillings	No coin	33⅓ cents.*
Two shillings and sixpence	No coin	41⅔ cents.*
Three shillings	American or Spanish coin	50 cents.
Three shillings and sixpence	No coin	58⅓ cents.*
Four shillings	No coin	66⅔ cents.*
Four shillings and sixpence	American or Spanish coins	75 cents.
Five shillings	No coin	83⅓ cents.*
Five shillings and sixpence	No coin	91⅔ cents.*
Six shillings	American or Spanish coins	$1.00
Nine shillings	American or Spanish coins	$1.50
Ten shillings and sixpence	American or Spanish coins	$1.75

The foregoing table illustrates the peculiar tendency of the original New England people to adhere to old forms of speech and old names of familiar objects. After the first issue of our national coins they necessarily called them, as coins, by the names which our Congress had authoritatively given them, and they also used the official designations and values exclusively in keeping their accounts, just as we now do. In colloquial speech, however, they continued to use the English monetary terms of their ancestors for all values above five cents and up to a dollar and a half, whether the coins they had in hand were American or Spanish. For example, a merchant would tell his customer the prices of his goods in shillings and pence, and when the sale was made he would accept either American or Spanish coins in payment and turn to his cash book and enter the transaction in terms of our national currency only.

The respective values assigned to the shilling and pound in the New England bills of credit made it impracticable to recognize the cent as a single penny, because its value as one-twelfth of sixteen and two-thirds cents, became one and a third cents, but the penny was freely recognized and expressed in multiples. For example, the

* There were not only no coins in existence to represent these several values, but they could not be accurately represented by combinations of any coins of smaller values.

Spanish real, neglecting the half cent, became ninepence and the Spanish medio became fourpence and half-penny. It is worthy of special remark that for the terms penny, fourpence, sixpence, and shilling, which the New England people habitually used, there were no respectively corresponding coins in existence.

This persistence of the New England people in the use of the terms shillings and pence long after the establishment of our national monetary system is all the more remarkable, because that people had long before abandoned the use of all English coins, because they used those terms whether the coins employed by them were American or Spanish, and because an intense antipathy to England then prevailed among them. Their tendency to adhere to old customs, which has been referred to, made the English speech of my boyhood in Massachusetts decidedly dialectic. This is partially illustrated by the following table, which shows the dialectic pronunciation of the now archaic monetary terms which the New England people habitually used. These terms and their pronunciation pertained to the prevalent serious speech of the people and were in no way exceptional or frivolous. In view, however, of the present sufficiency of our national coins in circulation bearing appropriate and established names, and of the prevalent correctness of English speech, the present monetary use of any of the archaic terms which have been discussed in the foregoing paragraphs partakes of the nature of slang.

New England Dialectic Pronunciation of Archaic Monetary Terms

Monetary terms.	Dialectic pronunciation.
Cent	Cent.
Half-dime	Five cents.
Dime	Ten cents.
Four pence and half-penny	Fo'pns hăpny.
Sixpence	Sixp'ns.
Ninepence	Ninep'ns.
Shilling	Shillin.
One shilling and sixpence	One'n'six.
Two shillings	Two shillins.
Two shillings and sixpence	Two'n'six.
Three shillings	Three shillins.
Three shillings and sixpence	Three'n'six.
Four shillings	Four shillins.
Four shillings and sixpence	Four'n'six.
Five shillings	Five shillins.
Five shillings and sixpence	Five'n'six.
Six shillings	Six shillins.
Nine shillings	Nine shillins.
Ten shillings and sixpence	Ten'n'six.

DESCRIPTION OF A COLLECTION OF KOOTANIE PLANTS FROM THE GREAT FALLS COAL FIELD OF MONTANA[1]

By F. H. KNOWLTON

The present paper is based on a small collection of fossil plants obtained during the season of 1906 by Mr. Cassius A. Fisher, of the U. S. Geological Survey, while engaged in economic work on the coals of the Great Falls coal field and adjacent areas in north-central Montana. While not of great extent, this collection contains a number of very interesting things, among them a species of the genus *Protorhipis,* which has not previously been found in this country. There are also a number of species not before noted in the Kootanie of the United States, although present in the Canadian beds of this age, as well as several believed to be new to science.

Before passing to an enumeration of the plants, a brief review of previous collections of Kootanie plants may be of interest. The name Kootanie Series, so given from a tribe of Indians who formerly hunted in the country in which it occurs, was proposed in 1885 by Dr. George M. Dawson for a series of sandstones interbedded with shales and shaly sandstones, including occasional beds of conglomerate and a zone containing coal seams. The original area, which was about 140 miles in length and 40 miles in extreme breadth, is in the Rocky Mountain region of Alberta north of the forty-ninth parallel and south of the Bow River. The plants collected in these beds were reported on by Sir William Dawson,[2] who enumerated twenty-two forms with new species in the genera *Asplenium, Zamites, Ginkgo,* and *Taonurus.*

In the course of an examination of the Great Falls coal field, the late Dr. J. S. Newberry obtained fossil-plant data which, in 1887, enabled him to announce[3] that "these plants prove beyond question that the Great Falls coal basin is of the same age as those that have been described north of the boundary line by Dr. George M. Dawson, in what he has designated as the Kootanie series."

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[1] Published by permission of the Chief Geologist of the United States Geological Survey.

[2] Trans. Roy. Soc. Canada, vol. 4, 1885, sec. IV, pp. 5–10, pls. I, II.

[3] School of Mines Quarterly, vol. 8, July, 1887, p. 329.

Incident to the construction of the railroad from Helena to Great Falls, a considerable collection of plants was made in the cuttings near the latter town, which were reported on by Dr. Newberry in 1891.[1] In addition to eight species described as new and belonging to the genera *Chiropteris, Zamites, Baiera, Cladophlebis, Sequoia, Podozamites,* and *Oleandra,* Dr. Newberry listed thirteen species as common to the Great Falls field and the lower Potomac of Virginia, three as common to this locality and the Kootanie of Canada, and six as common to the Kome (Urgonian) beds of Greenland.

In 1890 Dr. A. C. Peale and the writer made a small collection of Kootanie plants from the vicinity of Great Falls and above the mouth of the Sun River, and the following year Mr. W. H. Weed made an additional small collection from the same place, which were studied by Prof. Wm. M. Fontaine, his report appearing in 1892.[2] He enumerated fifteen species and varieties, of which number six in the genera *Aspidium, Pecopteris, Cladophlebis,* and *Zamites* were regarded as new.

Also, in 1891, Dr. H. M. Ami and Dr. Hayden made a considerable collection of plants from the Kootanie of the Cascade coal basin of the Canadian Rockies, which were reported on by Sir William Dawson, whose report appeared in 1892.[3] This paper recorded twenty-one forms, of which two were new to science (*Pinus* and *Angiopteridium*) and eight not named specifically.

The final publication which it remains to notice was based on collections made during the years 1894 and 1895, the first by Mr. W. H. Weed and the last by Prof. Lester F. Ward, from a number of localities in Cascade County, Montana, largely in the vicinity of the stage station of Geyser and about forty miles southeast of Great Falls. These were turned over to Professor Fontaine for elaboration, and his report is published in Ward's second paper on the "Status of the Mesozoic Floras of the United States."[4] It includes sixteen species, of which five were described as new, the latter belonging to the genera *Dicksonia, Lycopodites, Cycadeospermum, Nagiopsis,* and *Laricopsis.*

On compiling a list of all the plants heretofore reported from the Kootanie beds of Canada and the United States, we have a grand total of ninety forms. It is more than probable, however, that if all

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[1] Am. Jour. Sci., 3d ser., vol. 61, 1891, pp. 191–201, pl. XIV.

[2] Proc. U. S. Nat. Mus., vol. XV, 1892, pp. 487–495, pl. LXXXII–LXXXIV.

[3] Trans. Roy. Soc. Canada, vol. 10, sec. IV, 1892, pp. 79–93, figs. (in text) 1–16.

[4] Monog. U. S. Geol. Survey, No. 48, 1905, pp. 284–315, pls. LXXI–LXXIII.

these scattered collections could be assembled and carefully compared, a number of forms now held to be different would be found identical. Thus, specimens from Geyser doubtfully identified by Fontaine as his *Cephalotaxopsis ramosa* prove to be a fern which I have described as *Oleandra graminæfolia,* and from merely inspecting the figures of what Dawson has determined as Heer's *Pinus* (*Cyclopitus*) *nordenskiöldi,* from Anthracite, British Columbia, I suspect it may also be referable to this fern; so, also, Newberry's *Baiera brevifolia* is apparently identical with what I have called *Ginkgo sibirica.*

The geological age of the Kootanie formation has never been much in question. In the first publication in which the formation received its name and where we are afforded the first view of its floral contents, Sir William Dawson says: "The Kootanie series should probably be placed at the base of the table as a representative of the Urgonian or Neocomian, or, at the very least, should be held as not newer than the Shasta group of the United States geologists and the Lower Sandstones and Shales of the Queen Charlotte Islands. It would seem to correspond in the character of its fossil plants with the oldest Cretaceous floras recognized in Europe and Asia, and with that of the Kome formation in Greenland, as described by Heer." In his latest pronouncement on the subject he placed it with little qualification in the Neocomian, while later Newberry and Fontaine inclined to correlate it with the Wealden, the latter stating that he regarded it as "being essentially of the same age as the Lower Potomac of Virginia," which he placed in the Wealden. The flora of the Kootanie contains species occurring in the uppermost Jurassic, the Wealden of England, the Kome of Greenland, and the Lower Potomac of Virginia, but from the fact that no traces of angiospermous plants have thus far been detected in the Kootanie, though occurring in the Lower Potomac, I should incline to agree with Newberry in regarding the Kootanie as slightly older than the Lower Potomac, though undoubtedly both are essentially in the position of the Wealden.

Following is a complete list of the localities whence came the material included in the following report:

(1.) First railroad cut west of smelter on high line track, north side of Missouri River, Great Falls, Montana. Collected by Prof. O. C. Mortson.

(2.) Same as last, but slightly different bed.

(3.) Flood siding 5 miles southwest of Great Falls, Montana. Collected by C. A. Fisher.

(4.) East side of Spanish Coulée (T. 17 N., R. 3 E.), 12 miles east of Cascade, Cascade County, Montana. Collected by C. A. Fisher and H. M. Eakin.

(5.) Brown sandy shale 2 feet above main coal bed at Smauch's mine, on east side of Belt Creek, at Belt, Cascade County, Montana. Collected by C. A. Fisher and H. M. Eakin.

(6.) Meridith mine, east side of coulée, about 3 miles southeast of Nollar's ranch and 6 miles southwest of Geyser, Cascade County, Montana. Collected by C. A. Fisher and M. R. Campbell.

(7.) Cañon on west side of Skull Butte, 6 miles southeast of Stanford, Fergus County, Montana. Collected by C. A. Fisher and D. E. Winchester.

ORDER FILICINÆ

CLADOPHLEBIS HETEROPHYLLA Fontaine

Cladophlebis heterophylla FONTAINE, Proc. U. S. Nat. Mus., vol. 15, 1892, p. 493, pl. LXXXIV, fig. 2; Fontaine in Ward, Monog. U. S. Geol. Survey, No. 48, 1905 [1906], p. 294, pl. LXXI, figs. 21–25.

Locality.—Cañon north side of Skull Butte, 6 miles southeast of Stanford, Fergus County, Montana; cut on Hazlett Creek 3 miles south of Bauer sheep ranch; Meridith mine, 3 miles southeast of Nollar's ranch and 6 miles southwest of Geyser, Cascade County, Montana.

CLADOPHLEBIS BROWNIANA (Dunker) Seward

PLATE XI, FIGS. 1, 1A

Cladophlebis browniana (DUNKER) SEWARD, Cat. Mesoz. Pl. Brit. Mus., Wealden Fl., pt. 1, 1894, p. 99, pl. VII, fig. 4.

The material from Skull Butte, eastern Fergus County, Montana, contains a number of fragments of pinnæ that appear to belong to this species. From the portions preserved it appears that the pinnæ must have been long and narrowly linear, with the pinnules contiguous and not cut quite to the rachis. The nervation is strong and well marked, consisting of a fairly strong midvein and some 8 or 9 pairs of rather close forking veins.

With such limited material at hand, it is hard to determine this fern with complete satisfaction. It is apparently of exactly the same type as *Cladophlebis heterophylla* Fontaine [1]—in fact, it seems hardly

[1] In Ward, Monog. U. S. Geol. Survey, No. 49, 1905 [1906], pl. LXXI, fig. 24.

more than a "large edition" of that species. As Seward has pointed[1] out, this species has a strong resemblance to *Gleichenia zippei* Heer[2] from the Lower Cretaceous of Greenland. In the absence of conclusive evidence, however, it seems best to keep it under the present name.

Locality.—Cañon north side of Skull Butte, 6 miles southeast of Stanford, Fergus County, Montana.

CLADOPHLEBIS CONSTRICTA Fontaine

Cladophlebis constricta FONTAINE, Monog. U. S. Geol. Survey, No. 15, 1889, p. 68, pl. II, figs. 11, 11*a*, 11*b*; pl. III, fig. 2; pl. VI, figs. 5, 5*a*, 6, 6*a*, 8–14; pl. XXI, figs. 9, 13; pl. CLXIX, figs. 2, 2*a*; Fontaine in Ward, Monog. U. S. Geol. Survey, No. 48, 1905 [1906], p. 297, pl. LXXI, fig. 26.

A single characteristic and well preserved example.

Locality.—Meridith mine, 3 miles southeast of Nollar's ranch and 6 miles southwest of Geyser, Cascade County, Montana.

CLADOPHLEBIS FISHERI n. sp.

PLATE XI, FIGS. 2, 2A

Outline of frond unknown, pinnæ linear, evidently long, the rachis very strong, with two or three minute ridges on the upper side; pinnæ cut nearly to the rachis into relatively large opposite or subopposite, triangular, subfalcate rather obtuse pinnules, with entire or slightly undulate margins; nervation very strong, consisting of a thick midvein, which is zigzag and passes to the apex or forks once or twice into nearly equal branches in the upper portion, with four or five pairs of alternate, strong, remote veins on either side, each of which forks once or twice in passing to the margin; surface between the veins showing minute pits or areolations.

The example figured is the only one found in the collection, and it is with some hesitation that I have decided to describe it as new on such scanty material. It appears to approach most closely to *Cladophlebis virginiensis* Font.,[3] from the Lower Potomac of Virginia, from which it differs in having the pinnules shorter, much broader and more obtuse, and the nervation apparently stronger. It is possible that a larger series of specimens might show that these differences break down, in which case it can be referred to the Virginia species.

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[1] Op. cit., p. 100.

[2] Fl. Foss. Arct., vol. 3, 1874, pls. V, VI, etc.

[3] Monog. U. S. Geol. Survey, No. 15, 1889, p. 70, pl. IV, figs. 1, 3–6.

Locality.—Meridith mine, 3 miles southeast of Nollar's ranch and 6 miles southwest of Geyser, Cascade County, Montana.

THYRSOPTERIS ELLIPTICA Fontaine

Thyrsopteris elliptica FONTAINE, Monog. U. S. Geol. Survey, No. 15, 1889, p. 133, pl. XXIV, fig. 3; pl. XLVI, fig. 1; pl. I, figs. 6, 9; pl. LI, figs. 4, 6*a*, 6*b;* pl. LIV, fig. 6; pl. LV, fig. 4; pl. LVI, figs. 6, 7; pl. LVII, fig. 6; pl. LVIII, figs. 2, 2*a;* Fontaine in Ward, Monog. U. S. Geol. Survey, No. 48, 1905 [1906], p. 290, pl. LXXI, figs. 12, 13.

Locality.—Spanish Coulée, 12 miles east of Cascade, Cascade County, Montana; Meridith mine, 3 miles southeast of Nollar's ranch and 6 miles southwest of Geyser, Cascade County; cut on Hazlett Creek 3 miles south of Bauer sheep ranch.

ACROSTICHOPTERIS FIMBRIATA n. sp.

PLATE XI, FIGS. 3, 3A

Size and outline of whole frond unknown; pinnæ probably long, linear, rachis exceedingly strong though possibly fleshy; pinnules alternate, rather remote, very broadly triangular or ovate in general outline, decurrent down the rachis nearly or quite to the one next below, exceedingly thin and delicate in texture; pinnules (at least lower ones) deeply cut into about four cuneate-flabellate lobes, each of which is provided with two or three strong, sharp teeth; nervation sparse, consisting of a short, strong midvein which almost immediately splits into three or four veins which with one or two forks pass to the points of the sharp teeth; upper pinnules apparently not lobed, but strongly and sharply toothed.

This species is represented only by the single specimen figured, and except for the fact that it is so strongly marked it would be unwise to characterize a species on such scanty material. It is quite unlike anything that has been previously reported from these beds.

As may be seen from the figure, this is a very peculiar fern. The thickness of the portion of the rachis preserved would imply that the pinnæ were of considerable length, whereas the pinnules are obviously very thin and delicate. Their most marked character, however, is the degree of lobation, the two or three lower pinnules being deeply cut into three or four long wedge-shaped lobes which are again cut into two or three strong, sharp teeth. The nervation is very plain, though sparse, consisting of a thickened midvein which extends but a short distance in the lower pinnules, where it breaks up into three or four branches, each of which is usually once or twice forked before their termination in the apex of the lobes or teeth.

There can be little doubt that this plant is correctly referred to the *Acrostichopteris* of Fontaine, thus proving another strong bond of affinity between the Kootanie and the Lower Potomac of Virginia. It is, for example, certainly generically similar to *Acrostochopteris parvifolia* Font.,[1] though it is much larger and has the teeth of the lobes larger and sharper. It is also strongly suggestive of *A. Ruffordi* Seward[2] from the Wealden of England; indeed, with a larger series of specimens for comparison, it is not at all impossible that they might be shown to be identical. As it is, the present species appears to differ in being slightly larger, not so much cut, and the lobes with stronger, sharper teeth.

Locality.—Meridith mine, 3 miles southeast of Nollar's ranch and 6 miles southwest of Geyser, Cascade County, Montana.

DRYOPTERIS MONTANENSIS (Fontaine) Knowlton

Dryopteris montanensis (FONTAINE) KNOWLTON, Bull. U. S. Geol. Survey, No. 152, 1898, p. 92.

Aspidium montanense FONTAINE, Proc. U. S. Nat. Mus., vol. 15, 1892, p. 490, pl. LXXXII, figs. 1–3; pl. LXXXIII, figs. 2, 3, 3*a*.

Locality.—First railroad cut west of smelter on high line track, north side of Missouri River at Great Falls; same locality, but slightly different bed; Flood siding 5 miles southwest of Great Falls, Montana [at or near type locality].

DRYOPTERIS? KOOTANIENSIS n. sp.

PLATE XI, FIGS. 4, 4A

Outline of frond unknown; pinnæ slender, linear; pinnules small, very remote, apparently alternate, oblique, strongly auricled on both upper and lower side, otherwise linear, obtuse at apex, attached at the slightly heart-shaped base; midrib slender; veins slender, rather remote, apparently once forked.

This species is represented by the single fragment figured, which shows a slender rachis with only about five pinnules. These, it will be observed, are very remote, and are remarkable in that they have a pronounced enlargement at the base on either side, though the point of attachment is apparently in a slightly heart-shaped base.

[1] Monog. U. S. Geol. Survey, No. 15, 1889, pl. CLXXI, figs. 3, 4.

[2] Cat. Mesoz. Pl. Brit. Mus., Wealden Fl., pt. 1, 1894, p. 61, pl. VI, fig. 3.

There is so little of this specimen available for examination that it is impossible to make out its real form or its position on the frond. It is possible that it is only an extremely auricled form of, for instance, *Cladophlebis constricta* Font.,[1] though in *Cladophlebis* the pinnules are supposed to be attached by their whole bases, whereas in the one under consideration the attachment is probably by only a minute portion of the base. As this species cannot be referred to *Cladophlebis,* I have placed it tentatively under *Dryopteris,* but we must await fuller material before it can be definitely placed.

Locality.—Meridith mine, 3 miles southeast of Nollar's ranch and 6 miles southwest of Geyser, Cascade County, Montana.

ADIANTUM MONTANENSE n. sp.

PLATE XII, FIGS. 1, 2

Outline of frond unknown; pinnules apparently opposite or subalternate, relatively large, short-petioled, reniform, margin cut into numerous large rounded lobes; primary nerves numerous (a dozen or more), equal, radiating, several times dichotomous.

This form is represented by a few fragments only, the best being figured. In the one shown in figure 1 there is seen to be a rather slender rachis with one pinnule attached by a very short petiole and another some distance above and on the same side which is not attached, but is possibly in nearly its original position. The other, shown in figure 2, exhibits two pinnules on opposite sides of the slender rachis, only one of which, however, shows the petiole attached. The outlines and nervation are very well shown in the figure.

This species is undoubtedly very closely allied to *Adiantum formosum* Heer,[2] from the Lower Cretaceous (Kome) of Greenland, though Heer supposed his species to be simple—that is, he found no evidence to show that the pinnules (or fronds) were ever attached to a rachis—whereas in the Kootanie form the frond was clearly compound, having the pinnules attached by a short petiole to a slender rachis. In size, shape, degree of marginal lobation, and nervation they are certainly very similar, and a well preserved suite of specimens might show even closer agreement. Neither Heer's species nor the one under consideration shows any trace of fruit, and hence the reference to *Adiantum* is based entirely on form and

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[1] In Ward, Monog. U. S. Geol. Survey, No. 48, pl. LXXI, fig. 26.

[2] Fl. Foss. Arct., vol. 3, 1874, p. 35, pl. III, figs. 1, 2.

nervation, but this does not impair its stratigraphic value, since it can be readily recognized in future.

It may be noted in passing that Heer's *Adiantum formosum* is antedated by *A. formosum* R. Brown [Prod. Fl. N. Holland], 1810, p. 155], a living species of Australia and New Zealand.

Locality.—Meridith mine, 3 miles southeast of Nollar's ranch and 6 miles southwest of Geyser, Cascade County, Montana.

OLEANDRA GRAMINÆFOLIA n. sp.

PLATE XI, FIGS. 5, 5A, 6, 6A

Cephalotaxopsis ramosa FONTAINE? in Ward, Monog. U. S. Geol. Survey, No. 48, 1905 [1906], p. 311, pl. LXXIII, fig. 8.
?Pinus (Cyclopitus) nordenskiöldi HEER. Dawson, Trans. Roy. Soc. Canada, vol. 10, 1892, sec. IV, p. 88, fig. (in text) 9.

Fronds detached, narrowly linear and grass-like, long acuminate at apex; [base not seen]; midrib relatively very strong; nerves fine, close parallel, at right angles to the midrib, forking once, usually just at the base; [fructification not seen].

This species is represented by a large number of detached fronds which are scattered over and matted together on and in the matrix. There are no complete fronds, nor any evidences of the manner in which they were attached, though quite a number show the apex, which is seen to be narrowly acuminate. The length was more than 4 cm., for there are fragments this long, though most of them are shorter, while the width is from 2 to 3 mm. The nervation is very difficult to make out, but where it can be observed it is found to consist of a very thick midrib and numerous close parallel veins which fork near their point of origin in the midrib; no fruit was observed.

To the casual observer these little detached and more or less matted fronds appear like the tangled leaves of grasses or the detached leaves of conifers (like *Pinus*), and it is only by the most careful scrutiny that their real nature can be made out. At first it was supposed that they must represent a small, very narrow-leaved *Tæniopteris,* but the forking of the veins close to the midrib seem to place them nearest the genus *Oleandra.* The fronds, however, are much smaller and narrower than in any living or fossil species known to me.

In working up the material from Geyser, Professor Fontaine noted the presence of a number of "detached leaflets," which he referred somewhat doubtfully to his *Cephalotaxopsis ramosa* of the Lower Potomac beds of Virginia. Fortunately this material is preserved in the U. S. National Museum (No. 31,711), and on looking at it critically it is found to be undoubtedly the same as the material in hand. It is indeed difficult to see how Professor Fontaine could have overlooked the fact that many of these supposed leaves of *Cephalotaxopsis* are at least twice the length of even the largest leaves of the Virginia species.

In his report on the Kootanie plants from Anthracite and Canmore, British Columbia, Dawson[1] has figured a mat of long, narrow leaves which he refers to Heer's *Pinus* (*Cyclopitus*) *nordenskiöldi*. I have not seen this material, but, judging from the drawing alone, I am decidedly of the opinion that it should be referred to *Oleandra*.

Locality.—Meridith mine, 3 miles southeast of Nollar's ranch and 6 miles southwest of Geyser, Cascade County, Montana.

CHIROPTERIS SPATULATA Newberry

Chiropteris spatulata NEWBERRY, Am. Jour. Sci., 3d ser., vol. 61, 1891, p. 199, pl. XIV, figs. 1, 2.

Locality.—Spanish Coulée, 12 miles east of Cascade, Cascade County, Montana.

PROTORHIPIS FISHERI n. sp.

PLATE XII, FIGS. 3, 4

Leaves of small size and thick leathery texture; orbicular or perhaps nearly circular in outline, very deeply heart-shaped at base, the lobes broad and rounded; (margin unknown, possibly entire, but at most probably not more than dentate); petiole very thick and strong, forking or splitting at the very base of the lamina into two approximately equal branches, which turn abruptly nearly at right angles and apparently there forming for a short distance the basal margin of the lamina, and thence continuing apparently to the lateral margin of the leaf; each main branch forks almost immediately, the branches passing up to supply the middle line of the blade, forking two or three times before reaching the apparent margin; from both sides of the main branches are several forks, the resulting branches supplying the rounded broad lobes and the lateral areas; the finer nervation consists of cross-nervilles approximately at right angles to the primary nerves, enclosing large areas which are filled with nearly as strong approximately quadrangular areolation; in one of

[1] Trans. Roy. Soc. Canada, vol. 10, 1892, sec. IV, p. 88.

the specimens the spaces between the veins are filled with the minute areolation, with little or no evidence of the slightly stronger cross-veinlets.

This species is represented at present by only two specimens, neither of which, unfortunately, is sufficiently well preserved to permit its complete description. So far as can be made out, these leaves were approximately circular or possibly broadly reniform in outline. In the larger example the length from the top of the petiole to the upper margin is about 2 cm., while the greatest apparent width is about 3.5 cm., but as it is very deeply heart-shaped, the general outline becomes approximately circular. The same dimensions in the smaller example are 1.75 cm. and about 2.5 cm., though again the deeply cordate base about restores the circular outline. The very thick petiole is nearly 1 cm. in length and is probably not fully preserved. The margin is not certainly preserved except for a short distance on the base of the basal lobes. It is impossible to determine the character of the margin on the lateral and apical portions, though if not entire it could hardly have been more than strongly dentate.

The nervation, as pointed out under the diagnosis, is very peculiar, all, including the ultimate ramifications, being very deeply impressed, thus showing the leaf to have been thick in texture. The primary nervation is always clearly and distinctly forked, the petiole being first forked at the point of entrance into the lamina, and from each of these branches arise the several (6 or 8) thick branches which may be observed at the base of the blade, these spreading and again forking two or three times before reaching the margin, the whole filling fairly evenly the area of the leaf. The character of the ultimate nervation is well shown in the figures.

As this is the first time the presence of *Protorhipis* has been noted in this country, at least as such, and as the affinities and interrelationships are still somewhat an open question, it may be worth while to pass briefly in review the distribution and history of the genus. *Protorhipis* was established by Andrae in 1853,[1] the type specimen (*P. buchii*) being from the Jurassic (Lias) of Steierdorf, in Banat, Hungary. It was a large leaf, some 10 or 12 cm. in width, semi-orbicular in shape, with a strongly sinuate-toothed margin. The base of the leaf was not preserved, but the primary nervation consists of strong, palmately disposed forked ribs or veins, the area between the veins being filled with a coarse quadrangular areolation.

[1] Fossile fl. Siebenbürgens u. d. Banates. Abl. k. k. geol. Reichs., vol. 2, abth. 3, No. 4, 1853, p. 35, pl. VIII, fig. 1.

This form was placed by its author among the ferns and compared especially with the living *Platycerium*.

The next species in point of time is *Protorhipis asarifolia*, described in 1865 by Zigno,[1] from the Jurassic (Oölite) of Italy. It is very much smaller than the type species, being only about 3 cm. in diameter. It is nearly circular in outline, deeply kidney-shaped at base, and has the margins perfectly entire; it was also placed among the ferns.

In 1878 Nathorst[2] described two small forms from the Jurassic (Rhetic) of Bjuf, Sweden. At first he inclined to refer one to *P. buchii* of Andrae, but later described both as new, under the names *P. crenata* and *P. integrifolia*. They are much smaller than the type species, and were also regarded as belonging among the ferns.

Two years later Heer[3] described his *P. reniformis* from the Oölite of Siberia, this being a small reniform, entire-margined species strikingly similar to Zigno's *P. asarifolia*. In 1882 the same author described another species, under the name of *P. cordata*,[4] from the Kome beds (Urgonian) of Kome, Greenland. It also belongs to the same group with *P. reniformis* and *P. asarifolia*.

In his final paper on the Mesozoic floras of Portugal, published in 1894, Saporta gave complete descriptions and figures of his curious and in some ways anomalous *Protorhipis choffati*,[5] which comes from the Urgonian of Cercal. It is very different from the forms previously referred to *Protorhipis*, and, as he suggests, has a rather striking resemblance to certain bracts, stipules, or involucral expansions of some angiosperms, as well as to certain ferns, such as *Platycerium*. Its nature and position can hardly be considered as settled. In the same paper[6] Saporta took occasion to describe and figure a very fragmentary specimen from Bjuf, Sweden, submitted to him by Nathorst, under the name of *Protorhipis nathorstii*. It is too imperfect to admit of very careful diagnosis and may very probably belong to some of the forms of this or the related genus, *Hausmannia*, already described from those beds.

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[1] Fl. Foss. Form. Oolithcæ, vol. I, 1865, p. 180, pl. IX, figs. 2, *2a*.

[2] Fl. v. Bjuf, pt. I, p. 42; pt. II, p. 57, pl. XI, figs. 2, 4.

[3] Mem. Acad. Imp. d. St. Petersbourg (7 ser.), vol. 27 (Fl. Foss. Arct., vol. 6, Abth. I, pt. I), 1880, p. 8, pl. I, fig. *4a*.

[4] Fl. Foss. Arct., vol. 6, Abth. 2, p. 10, pl. III, fig. II.

[5] Fl. Foss. Portugal, 1894, p. 144, pl. XXII, figs. 9–11; pl. XXVI, figs. 17, 18; pl. XXVII, figs. 1–5.

[6] Op. cit., p. 143, pl. XXII, figs. 14, *14a*.

The genus *Hausmannia,* instituted by Dunker,[1] in 1846, from an imperfect leaf from the Wealden of North Germany, is also involved in the present complication. The type species, and apparently the latest species to be referred to *Protorhipis,* is *Dictyophyllum roemeri* Schenk, which is recorded by Seward[2] from the Wealden of Bernissart, Belgium, under the name *P. roemeri.* It is a mere fragment and can have no value one way or the other.

H. dichotoma is very different in appearance from *Protorhipis buchii,* the type of the former genus being palmate and deeply divided into lobed linear segments, which are traversed by forked main veins from which anastomosing branchlets are given off. A number of species were subsequently described under this generic name and which conform to the original generic diagnosis, but in 1892 Bartholin described from Bornholm, as *Hausmannia forchhammeri,* a number of specimens that were obviously the same as *Protorhipis buchii.* In commenting on this paper, Zeiller[3] took occasion to state that he had received additional material from the type locality of *Protorhipis buchii* Andrae, which he identified with that species; this material he illustrated by a number of good photographs. He states, and the figures certainly bear him out, that this new material shows the species to be deeply bilobed or cut quite after the manner of living *Dipteris* fronds, to which they are certainly most closely related; and, further, that while apparently differing markedly from Andrae's type specimens, it simply proves that species to be polymorphous, some leaves agreeing with the type and others showing more or less lobing or cutting. If this be true, there is obviously no ground for maintaining the genus *Protorhipis,* as *Hausmannia* has priority, and this is the view adopted by Möller,[4] who has recently worked over the Bornholm flora. He describes and figures at length the *Hausmannia forchhammeri* of Bertholin, and specially a new form of it which he denominates subspecies *dentata.* The latter is evidently similar to the *type* of *Protorhipis buchii,* while the other forms referred to *H. forchhammeri* exhibit to a greater or less extent the lobing supposed to be characteristic of *Hausmannia.* It may be that we really have here a highly polymorphous aggregate, as indeed Saporta suggested, one portion of the plant, or one stage in its growth, showing rounded, unlobed, and at most dentate-margined

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[1] Monog. Norddeutschen Wealdenfl., 1846, p. 12, pl. v, fig. 1.

[2] Mem. Mus. Hist. Nat. Belgique, vol. 1, 1900, p. 18, pl. III, fig. 34.

[3] Rev. Gén. d. Botanique, vol. 9, 1897, p. 51 (reprint), pl. XXI, figs. 1–5.

[4] Kongl. Fysiogr. Sällsk Handl., vol. 13, 1902, p. 48.

leaves, and at another more or less profoundly lobed and cut leaves. There is of course abundant precedent for this condition among living ferns and dicotyledons, but I am free to confess that the evidence thus far presented does not seem to my mind sufficiently conclusive to warrant this sweeping contention, and I prefer to hold with Seward, that "it is convenient to retain the name *Protorhipis* for certain species of Wealden and Jurassic ferns," especially for some of the smaller entire or dentate-margined forms, which do not appear to have been cut or lobed after the manner of normal *Dipteris* fronds. With imperfect or fragmentary material, it may sometimes be difficult to distinguish between *Protorhipis* and *Hausmannia*, and the possibility that the generic distinctness does not exist is admitted; but with good material it should not be so. Although the nervation seems the same in both Andrae's and Zeiller's specimens from Steierdorf, judging from the figures given by both authors, it does not seem to me that it has been established beyond all doubt that they come from the same plant.

The question now comes as to the position of what I have here called *Protorhipis fisheri*. In size and shape it approaches most closely to *P. asarifolia* Zigno, *P. reniformis* Heer, and *P. cordata* Heer, but it seems to be extremely doubtful if either of these species has anything to do with *Protorhipis* as founded by Andrae, as Möller, Nathorst, and others have suggested. Indeed, Nathorst thinks it probable that Heer's *P. reniformis* is a scale, possibly of some species of *Zamiostrobus*, and the same may apparently be said of the others. The nervation in the three forms above mentioned, when it can be made out, is quite unlike that of typical *P. buchii*. The nervation of *P. fisheri*, on the other hand, is of the same character as that shown in the type of *P. buchii*, the main veins being several times forked and the intermediate areas filled with a strong quadrangular areolation. Unfortunately it is impossible to determine the character of the margin in *P. fisheri*, but it could hardly have been more than dentate, and there is certainly no evidence to show that it could be a portion of a deeply bilobed or cut leaf. It may be necessary to establish a new genus for the leaves under consideration, in the event that the typical forms of *Protorhipis* are incontestably proved to be indistinguishable from *Hausmannia*.

It further remains to consider the systematic position of the leaves here called *Protorhipis*. As already indicated, *Protorhipis buchii* was placed by Andrae among the ferns, on the ground of its resemblance to certain forms of the younger fronds of the living *Platycerium*. When the striking resemblance between this species and subsequently described forms of *Protorhipis* and the living *Dipteris* was noted, the grounds for referring it to the ferns were strengthened, and when, later, Bartholin found evidences of sori arranged as in *Dipteris,* as apparently did Zeiller, the matter came to be practically settled. However, when Saporta, in 1894, presented his final paper on the fossil flora of Portugal, he took occasion to pass in review the several species of typical *Protorhipis,* added a new one (*P. choffati*), and decided that while they of coure resembled the ferns, they might possibly be archetypal dicotyledons, and so placed them with some caution in his group of Proangiosperms. Professor Ward, in a subsequent paper on "Some Analogies in the Lower Cretaceous of Europe and America,"[1] not only accepted Saporta's view, but abandoned his caution and boldly referred the entire genus *Protorhipis* to the dicotyledons. As already noted, such species as *P. reniformis, P. cordata,* and *P. asarifolia* can hardly have any legitimate connection with typical *Protorhipis,* and their wholesale reference to the dicotyledons is certainly without warrant. When we take into account the undoubted close relationship between *Protorhipis* and *Hausmannia* and the demonstrated affinity between the latter and the living *Dipteris,* it is seen that the grounds for regarding any of these fossil forms as primitive dicotyledons are very slight indeed. Even Saporta's *P. choffati,* which he compared to numerous living forms, is thought by Seward to be a fern, since it resembles especially the "bracket leaves" of *Platycerium.* It certainly does not belong to the genus *Protorhipis* as gauged by the type species.

Inasmuch as the flora of the Kootanie shows a strong affinity with that of the older Potomac of the Eastern States, it may be well to compare the species under discussion with certain supposed primitive dicotyledons described and figured by Fontaine,[2] such, for instance, as his *Proteæphyllum reniforme, P. orbiculare,* and *Populophyllum reniforme,* but it needs but a glance to show that they are not at all related to *Protorhipis fisheri.* While they agree fairly well in size and shape, the primary nervation is entirely different, being in the Virginia forms not only much more abundant, but distinctly reticulated, which in the former it never is.

I therefore reach the conclusion that the form here described as *Protorhipis fisheri* is to be placed among the ferns, and it is regarded as generically similar to *Protorhipis buchii.* It is named in honor

[1] Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 535.

[2] Monog. U. S. Geol. Survey, No. 15, 1889.

of the collector, Mr. Cassius A. Fisher, of the U. S. Geological Survey.

Locality.—Cañon north side of Skull Butte, 6 miles southeast of Stanford, Fergus County, Montana.

ORDER EQUISETACEÆ

EQUISETUM PHILLIPSII (Dunker) Brongniart

Equisetum phillipsii (DUNKER) BRONGNIART, *cf.* Fontaine in Ward, Monog. U. S. Geol. Survey, No. 48, 1905[1906], p. 298, pl. LXXII, figs. 1–11.

The only trace of this species noted on the collection is a small detached diaphragm such as that figured by Fontaine (loc. cit.), pl. LXXII, figure 4.

Locality.—In excavation of B. & M. smelter, Great Falls, Montana, below red shale.

ORDER CYCADACEÆ

PODOZAMITES LANCEOLATUS (L. & H.) Schimper

PLATE XIV, FIG. 4

Podozamites lanceolatus (L. & H.) SCHIMPER, Pal. Vég., vol. 2, 1870, p. 160.

This species has been noted by Dawson in the Kootanie of British Columbia, but not before detected in beds of this age in the United States.

Locality.—Meridith mine, about 3 miles southeast of Nollar's ranch and 6 miles southwest of Geyser, Cascade County, Montana.

PODOZAMITES NERVOSA? Newberry

Podozamites nervosa NEWBERRY, Am. Jour. Sci., 3d.ser., vol. 61, 1891, p. 200, pl. XIV, fig. 6.

Newberry's species was founded on a single leaflet which was four inches in length, being "broadest toward the base, subacute at the summit, with the nerves parallel, distant, strong." The collection in hand contains a single fragment, evidently from near the base of a very large leaflet, that can hardly be referred to anything but the present species. It of course adds nothing to our knowledge, and I have even thought it best to question the determination.

Locality.—Flood siding 5 miles southwest of Great Falls, Montana [at or near type locality].

ZAMITES ARCTICUS Göppert

Zamites arcticus GÖPPERT, Neues Jahr. f. Min., etc., 1866, p. 134, pl. II, figs. 9, 10; Fontaine in Ward, Monog. U. S. Geol. Survey, No. 48, 1905 [1906], p. 306, pl. LXXIII, figs. 1–6.

The status of this species in the Kootanie areas of the United States has been completely set forth by Professor Fontaine (loc. cit.), and it is unnecessary to go over the ground here. It is an abundant species in the present collection, in some instances being the only form present at certain localities.

Locality.—Brown sandy shale 2 feet above main coal at Smauch's mine, Belt Creek, Belt, Cascade County, Montana (only species present); Meridith mine, 3 miles southeast of Nollar's ranch [base of main coal]; cut on Hazlett Creek 3 miles south of Bauer's sheep ranch [43 feet below main coal].

ZAMITES APERTUS Newberry

PLATE XIII, FIG. 5

Zamites apertus NEWBERRY, Am. Jour. Sci., 3d ser., vol. 61, 1891, p. 199, pl. XIV, figs. 4, 5.

In seeking to identify the numerous specimens of *Zamites* in this collection I have been confronted with apparently the same difficulty that Professor Fontaine encountered, namely, a considerable number of so-called species to choose from and the difficulty of locating them definitely under either. Thus from the Canadian Kootanie Dawson reported *Z. acutipennis* Heer, *Z. montana* Dawson, and a form not specifically named, but which Fontaine[1] has placed under *Z. arcticus* Heer. In addition to these we have Newberry's *Z. apertus*, from the Great Falls area. As Fontaine very well says, it is more than probable that all of these (with the possible exception of *Z. apertus*) should be referred to *Z. arcticus* Heer; for, while it is possible to note minor differences, they are obviously of little value in considering a group in which there is known to be such variation as in cycad leaves. But with *Z. apertus* it is a little different, for while Newberry compared his species to *Z. arcticus,* he stated that it was "much more open in structure, the pinnules being separated by spaces sometimes as wide as themelves." I have not seen anywhere figures referred to *Z. arcticus* in which the leaflets are so widely separated, and for this confessedly doubtfully sufficient rea-

[1] In Ward, Monog. U. S. Geol. Survey, No. 48, 1905 [1906], p. 306.

son I have decided to recognize Newberry's species. A larger series would be quite likely to show that this supposed distinction is not valid.

Dr. Newberry was not able to note the nervation in the leaflets, as the nerves were "sunk in the parenchyma," but in one of the specimens before me which is exceptionally well preserved, it appears that there are always four strong nerves, between which are a large number of very fine faint nerves.

In some cases the specimens are so well preserved that the actual epidermal substance of the leaflet is retained as a thin, delicate, carbonaceous film, which can often be pulled off almost entire.

At my request Dr. Albert Mann, of the U. S. Department of Agriculture, who is especially skilled in all branches of microscopic technique, has kindly undertaken to prepare microscopical slides of these carbonaceous films, and the result has been entirely satisfactory, the epidermal structure being plainly revealed. In the irregularity of the cell outline, character and disposition of stomata, etc., they agree very closely with similar structures described in various fossil cycads,[1] but Dr. Mann has called my attention to the fact that the structure differs entirely from that of certain living species to which the plants are supposed to be related. The subject is therefore deferred to a subsequent paper, in which it is hoped to present the evidence in full.

Locality.—Spanish Coulée, 12 miles east of Cascade, Cascade County, Montana?

In addition to the above, there are two or three fragmentary specimens doubtfully referred to this species from cut on Hazlett Creek 3 miles south of the Bauer sheep ranch.

PTEROPHYLLUM MONTANENSE (Fontaine) n. comb.

PLATE XIV, FIG. 3

Zamites montanensis FONTAINE, Proc. U. S. Nat. Mus., vol. 15, 1892, p. 494, pl. LXXXIV, fig. 4.

Professor Fontaine based his species on a drawing of a single imprint, and as this was preserved with the lower side of the leaf uppermost, the insertion of the leaflets was concealed by the thick midrib. It was therefore impossible to decide whether the species should be referred to *Zamites* or *Pterophyllum;* but as it appeared

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[1] *cf.* Schenk, Palæontographica, vol. 19, 1871, p. 233 [31], pl. XXXV [XV].

to agree best with certain species of *Zamites,* it was referred provisionally to this genus.

According to Heer, Saporta, and others, the leaflets in *Zamites* are inserted on the upper surface of the rachis and are more or less contracted or inequilateral at base. In *Pterophyllum* the narrow leaflets are attached, usually at a right angle, by their entire bases to the edge of the rachis and are free throughout.

The present collection contains two well preserved specimens, one of which fortunately shows the upper surface of the leaf, and from this it is ascertained that the leaflets are attached by their bases to the edge of the rachis, thus throwing the species into *Pterophyllum,* to which I have accordingly transferred it. The two specimens here mentioned are preserved in small nodules, which when broken open exhibit nearly the complete leaf in an admirable state of preservation.

There are also several examples preserved in a soft shale that seem to belong here. They have, as may be seen from the figure, slightly narrower and rather more acuminate leaves, but the difference is probably too slight to warrant separating them. As a matter of fact, they do resemble Heer's *Zamites speciosus*[1] about as closely as the present species, but there is no evidence to show that the leaflets are not attached along the side of the rachis, and, moreover, the nervation, said by Heer to be obsolete in his *Z. speciosus,* is the same as in *Pterophyllum montanense.*

Locality.—Flood siding 6 miles southwest of Great Falls, Montana [at or near type locality]. Collected by Prof. O. C. Mortson, Spanish Coulée, 12 miles east of Cascade, Montana.

NILSONIA SCHAUMBURGENSIS (Dunker) Nathorst

Nilsonia schaumburgensis (DUNKER) NATHORST, Anzeiger d. k. Akad. d. Wiss. in Wien, Jahrg. 26, 1889, p. 237; Fontaine in Ward, Monog. U. S. Geol. Survey, No. 48, 1905 [1906], p. 303, pl. LXXII, figs. 17–21.

The specimens obtained at Geyser are discussed at length by Professor Fontaine, and the present specimens add nothing of interest.

Locality.—Meridith mine, 3 miles southeast of Nollar's ranch and 6 miles southwest of Geyser, Cascade County, Montana.

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[1] Fl. Foss. Arct., vol. 3, 1874, p. 64, pl. XIV, figs. 1–12; pl. XVI, fig. 4.

ORDER GINKGOACEÆ

GINKGO SIBIRICA Heer

PLATE XIII, FIGS. 1–4; PLATE XIV, FIGS. 1, 2

Ginkgo sibirica HEER, Fl. Foss. Arct., vol. 4, 1878, Abth. II, p. 61, pl. VII, fig. 6; pl. IX, fig. 5*f*; pl. XI.

Baiera brevifolia NEWBERRY, Am. Jour. Sci., 3d ser., vol. 61, 1891, p. 199, pl. XIV, fig. 3.

The present collection contains such a bewildering array of excellently preserved *Ginkgo* leaves that I am almost at a loss to know how best to dispose of them. Individual specimens can be so satisfactorily matched with various described forms that it would be little trouble to recognize perhaps as many as four or five so-called "species"; but no one who has examined a good series of leaves from a tree of the living species (*G. biloba*) can fail to recognize the danger in this genus of basing species too closely on size, shape, or the degree of lobation. In fact, it has been said that every described fossil species of *Ginkgo* can be very closely approximated by leaves from the living tree, and from evidence that has been accumulating of late there is every reason to believe that the extreme variation now exhibited has been a character of *Ginkgo* since its establishment. It is of course true that a few dominant forms of types can be recognized, and these may be—probably correctly—accepted until we have secured collections of a sufficient magnitude to permit the working out of the limits of legitimate specific variation.

It is with some hesitation that I have decided to refer these leaves to *Ginkgo sibirica* of Heer. The types of the species described from the Jurassic of eastern Siberia are rather more deeply lobed than the Kootanie specimens in hand, though they agree very well with leaves that have been subsequently referred to it, such, for instance, as the leaf figured by Saporta[1] from the Jurassic of France, and it is certainly the same as the leaf from the Canadian Kootanie figured by Dawson[2] under this name. In the same publication Dawson has also noted the presence of *Ginkgo lepida, G. nana,* and *Baiera longifolia;* but, judging from the figures alone, it is very doubtful if these can be maintained; certainly the specimens referred to *Ginkgo lepida* and *Baiera longifolia* must be identical, while his *G. nana* is probably the same, though it is too fragmentary to be positive one way or the other.

[1] Pal. Française, Pl. Jurass., vol. 3, pl. XXXII, fig. 6.

[2] Trans. Roy. Soc. Canada, vol. 4, sec. IV, 1885, p. 8, pl. II, fig. 1.

Certain of the specimens from Montana agree also with some of the forms that have been referred to *Ginkgo digitata* (Brongn.) Heer, and with fewer specimens there would probably be no hesitation in so referring them, but they grade one into the other to such an extent as to make any line unsatisfactory.

There are a number of small specimens (*cf.* plate XIV, figs. 1, 2) that are absolutely indistinguishable from *Ginkgo polaris* Nathorst[1] except in possessing a long, strong petiole. As Nathorst has suggested, his species can be especially compared with *G. sibirica* Heer and *G. flabellata* Heer; so that, as he naïvely adds, "there is the temptation of classing some fragments with one species, some with the other." As the more perfect examples appeared to differ from either in the petiole being neither so long nor strong, he decided to give it a separate name. As the specimens under consideration are otherwise indistinguishable, their having a relatively long and very strong petiole may properly exclude them from *G. polaris.*

In his first paper on the Great Falls coal field, Newberry described a deeply lobed leaf as *Baiera brevifolia,* comparing it especially with *B. pluripartita* Schimper, from the Wealden of North Germany. I have not seen this specimen, and the figure of it is so poor that nothing of the nervation can be made out, but I can see no reason to suppose it is other than a small leaf of *Ginkgo,* especially as it can be matched satisfactorily by specimens before me. I have therefore referred it tentatively to *G. sibirica.*

Finally, I may add that I have given on the plate a number of figures showing the normal and extremes exhibited, and while it must be confessed some of them are very unlike what has usually been referred to *Ginkgo sibirica,* there are so many intermediate forms that it is quite impossible to draw any satisfactory line between them. They must either be regarded as belonging to one polymorphous species or to half a dozen poorly defined forms.

Locality.—Shale below main coal seam, 3 miles southeast of Nollar's ranch, at Meridith mine, and about 6 miles southwest of Geyser, Cascade County, Montana. Mr. Fisher also noted, but did not collect, this species opposite the smelter, on the south bank of the Missouri River at Great Falls.

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[1] Norwegian North Polar Exped., 1893–1896, Foss. Pl. from Franz Josef Land, p. 4, pl. 1, fig. 8.

ORDER CONIFERÆ.

SEQUOIA GRACILIS Heer

Sequoia gracilis HEER, Fl. Foss. Arct., vol. 3, 1873, Abth. II, p. 80, pl. XVIII, fig. 1; pl. XXII, figs. 1–10.

This species, described originally from the Kome (Urgonian) beds of Greenland, was first detected in the Kootanie at Great Falls by Newberry. The present collections contain it from these localities, some of the specimens being especially well preserved and agreeing perfectly with the figures from the Greenland beds.

Locality.—Flood siding 5 miles southwest of Great Falls; north side of cut on high-line railroad west of smelter at Great Falls; Spanish Coulée, 12 miles east of Cascade, Cascade County, Montana.

SEQUOIA AMBIGUA Heer

Sequoia ambigua HEER, Fl. Foss. Arct., vol. 3, 1874, Abth II, p. 78, pl. XXI, figs. 1–11.

Locality.—Railroad cut west of smelter, north side of Missouri River at Great Falls, Montana.

SEQUOIA REICHENBACHI (Geinitz) Heer

PLATE XII, FIGS. 7, 8

Sequoia reichenbachi (GEINITZ) HEER, Fl. Foss, Arct., vol. 1, 1868, p. 83, pl. XLIII, figs. *1d, 2b, 5a*.

The collection made at Skull Butte, eastern Fergus County, contains a considerable number of rather fragmentary branchlets that appear to belong to this species, though the leaves are rather more spreading than is usual in *S. reichenbachi*. It is not, however, greatly different from certain of the forms referred to it by Heer from the Lower Cretaceous of Greenland.[1] There is also with these branchlets a very fragmentary cone that may belong with them; it is too much broken to figure.

Locality.—Cañon on north side of Skull Butte, 6 miles southeast of Stanford, Fergus County, Montana.

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[1] *cf.* Fl. Foss. Arct., vol. 3, 1874, pl. XX.

CONIFEROUS LEAVES?

Plate XII, Figs. 5, 6

The material from Skull Butte, eastern Fergus County, Montana, contains a number of isolated but fairly well preserved leaves that appear to have belonged to some conifer. They are about 13 or 14 mm. in length and slightly over 2 mm. in width, the basal portion being truncate or slightly rounded and the apical end rather obtusely acuminate. They are provided with a single quite prominent median rib. I have not attempted to place them more definitely than indicated above, as they are too uncertain.

Locality.—Cañon north side of Skull Butte, 6 miles southeast of Stanford, Fergus County, Montana.

EXPLANATION OF PLATES

PLATE XI

FIG. 1. *Cladophlebis browniana* (Dunker) Seward.
1*a*. Enlarged pinnule of same, × 2.
2. *Cladophlebis fisheri* n. sp.
3. *Acrostichopteris fimbriata* n. sp.
3*a*. Enlarged pinnule of same, × 2.
4. *Dryopteris? kootaniensis* n. sp.
4*a*. Enlarged pinnule of same, × 2.
5. *Oleandra graminæfolia* n. sp.
5*a*. Enlarged portion of same, × 2.
6. *Oleandra graminæfolia* n. sp.
6*a*. Enlarged portion of same, × 2.

PLATE XII

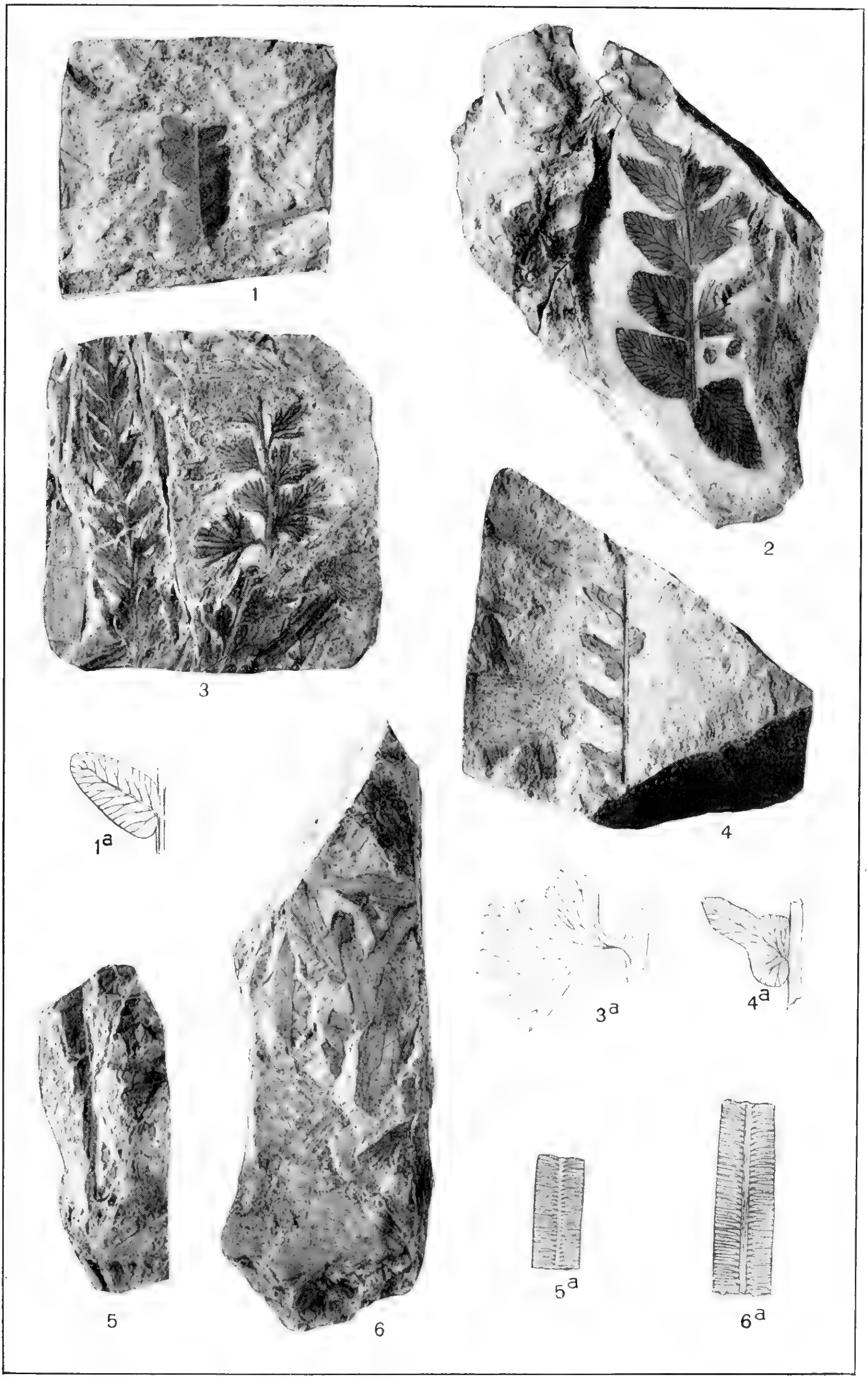
FIGS. 1, 2. *Adiantum montanense* n. sp.
3, 4. *Protorhipis fisheri* n. sp.
5, 6. Coniferous leaves.
7, 8. *Sequoia reichenbachi* (Geinitz) Heer

PLATE XIII

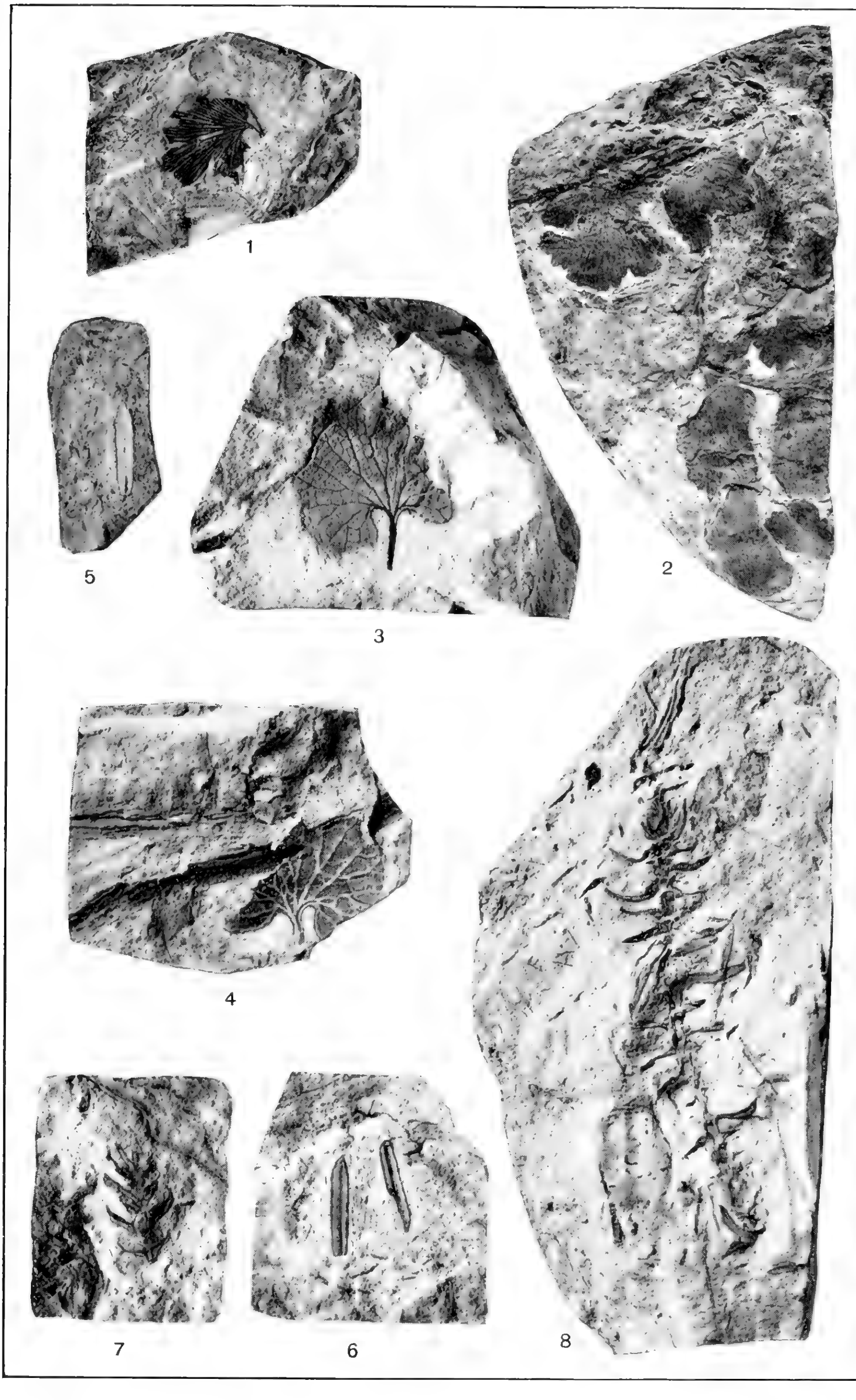
FIGS. 1–4. *Ginkgo siberica* Heer.
5. *Zamites apertus* Newberry.

PLATE XIV

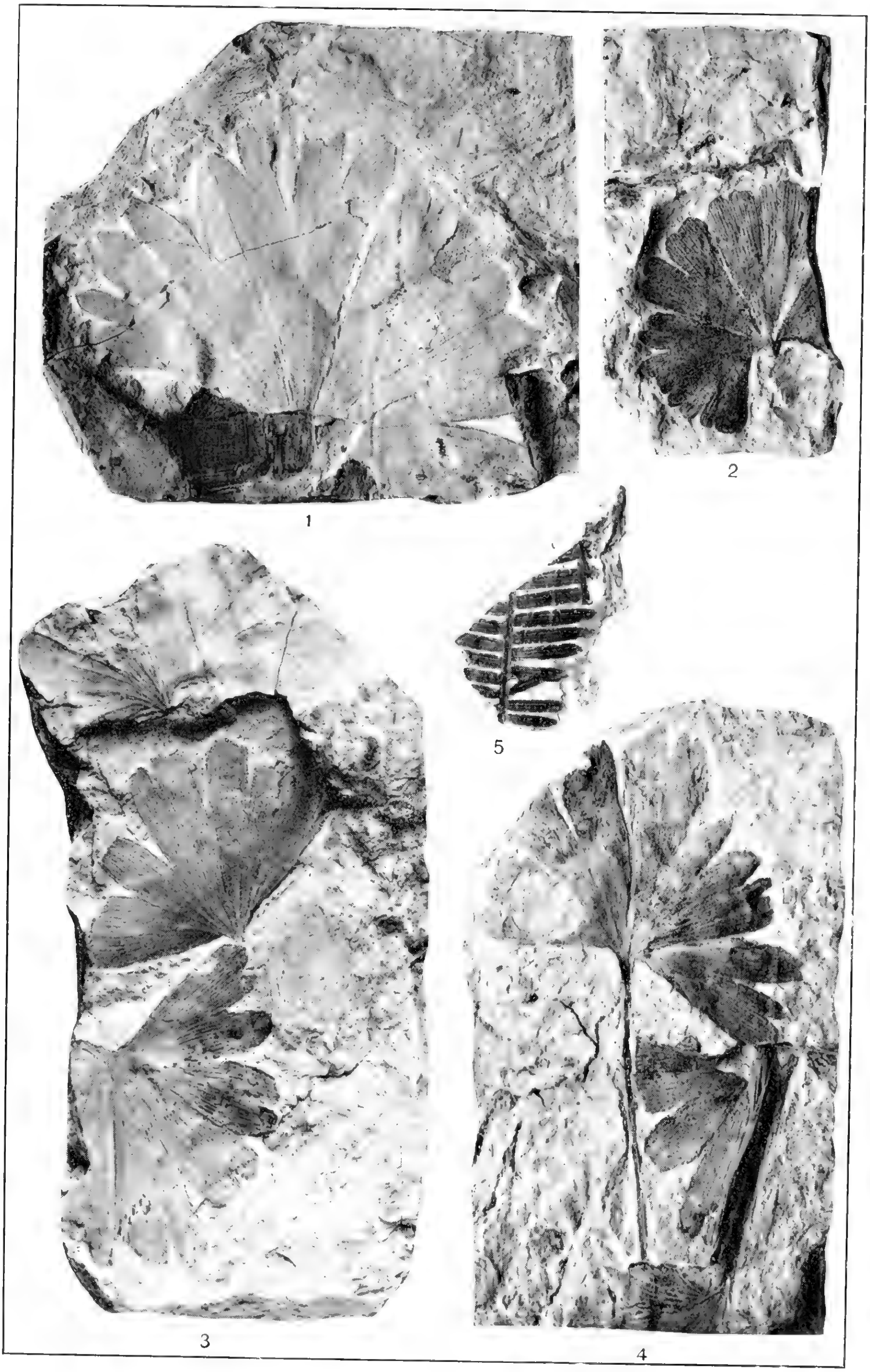
FIGS. 1, 2. *Ginkgo siberica* Heer.
FIG. 3. *Pterophyllum montanense* (Fontaine).
4. *Podozamites lanceolatus* (L. & H.) Nathorst.



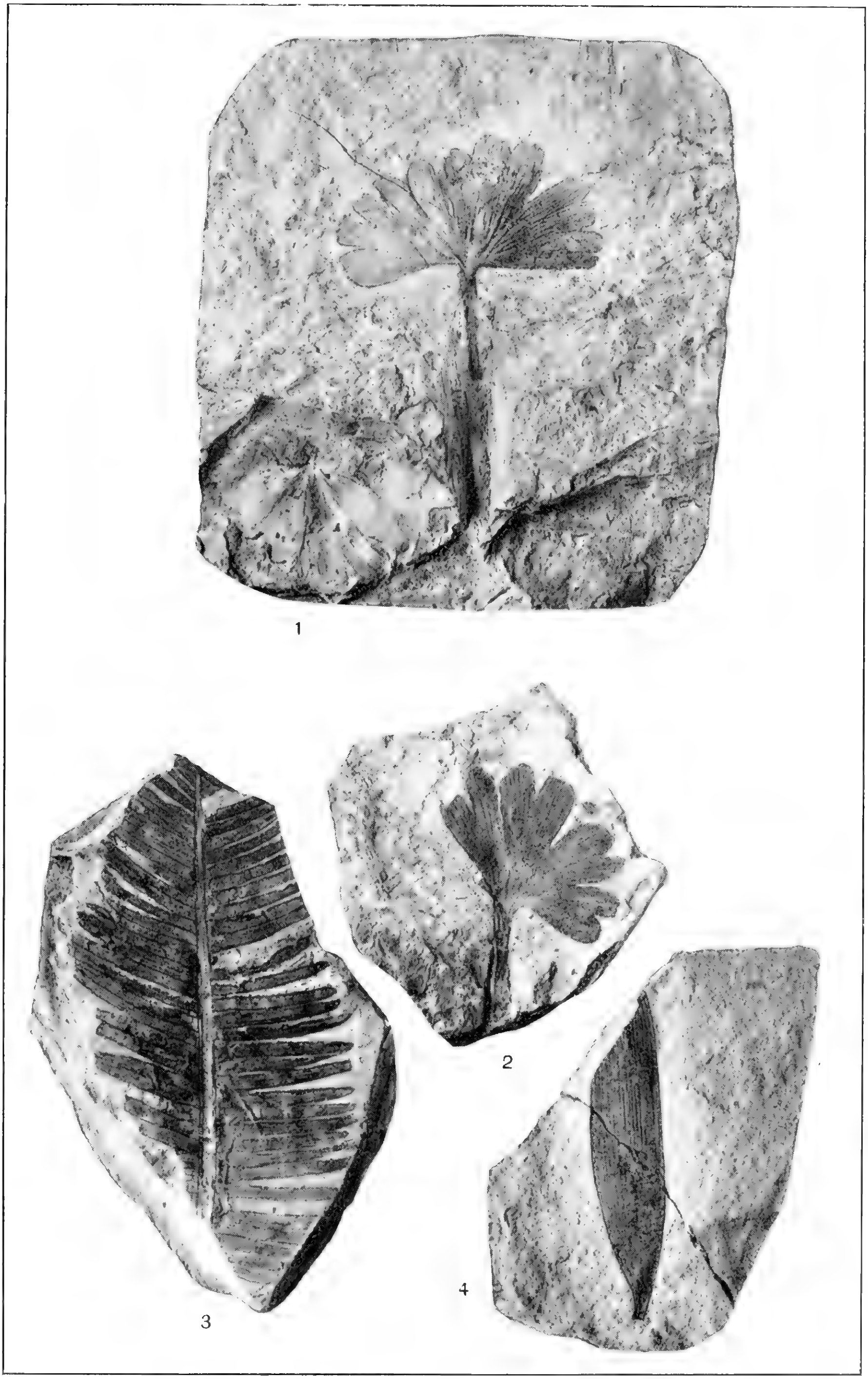
KOOTANIE PLANTS FROM THE GREAT FALLS COAL FIELD OF MONTANA



KOOTANIE PLANTS FROM THE GREAT FALLS COAL FIELD OF MONTANA



KOOTANIE PLANTS FROM THE GREAT FALLS COAL FIELD OF MONTANA



KOOTANIE PLANTS FROM THE GREAT FALLS COAL FIELD OF MONTANA

NOTES

Congress of Mathematicians

It is announced that a series of lectures on the present condition of the principal branches of mathematical science will be delivered by representative mathematicians of different countries at the Fourth International Congress of Mathematicians, to be held in Rome, April 6 to 10, 1908. Professor Simon Newcomb, U. S. N., has been requested to represent the Smithsonian Institution at this congress and has courteously accepted the designation.

Naples Zoölogical Station

Dr. Stewart Paton, formerly of Johns Hopkins University, whose occupancy of the Smithsonian seat in the Naples Zoölogical Station was extended through June of the present year, is now preparing a report of his research on the nervous system and its relation to the cardiac movements, for publication in parts. The whole work will be issued later in monograph form.

Professor Maynard M. Metcalf, of the Woman's College, Baltimore, occupied the Smithsonian seat at the station during the months of March and April, and has submitted an interesting report of his work while there. The research of Dr. Metcalf will be continued at Würzburg, Bavaria, and a summary of the results will be published on its completion.

Hodgkins Fund

Interesting researches aided by grants from the Hodgkins Fund of the Smithsonian Institution are now in progress.

Professor W. P. Bradley, of Wesleyan University, is still conducting an investigation on the factors which make for efficiency in the liquefaction of air. It is expected that the present work will be completed and reported on during the present year.

Mr. S. P. Fergusson, of Blue Hill Meteorological Observatory, has submitted a summary of his investigation of the differences between the meteorological conditions on the summits of mountains and at the same height in the free air. These experiments were aided by a moderate grant from the Hodgkins Fund.

An additional grant has been approved on behalf of Dr. von Lendenfeld, of the University of Prague, for the continuance of his investigation of the flight organs of insects. On completion of this research a report will be submitted for publication by the Institution. The present volume of the Quarterly Issue of the Smithsonian Miscellaneous Collections contains a report by Mr. Leo Walter "On the connection of the fore and hind wings of the Hymenoptera," this investigation having been conducted under the direction of Dr. von Lendenfeld.

Mr. C. M. Manly, formerly chief assistant in the aërodromic work conducted at the Smithsonian Institution, is completing the memoir of Secretary Langley on Mechanical Flight. This work will form an important addition to the interesting series of articles by Secretary Langley, on this and cognate subjects, already published.

The meteorological experiments with registering balloons conducted by Mr. A. L. Rotch, Director of Blue Hill Meteorological Observatory, are to be continued at St. Louis during the coming autumn and have been again aided by the Hodgkins Fund. Results of value to the science of meteorology are hoped for from this series of experiments.

The researches on sound by Dr. A. G. Webster, of Clark University, are still in progress. A moderate grant for the purchase of apparatus, which will revert to the Institution on the conclusion of the investigation, has recently been approved on behalf of Professor Webster.

PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

Continued from List in Quarterly Issue, Vol iii, Part 4.

No.	*Title.*	*Series.*	*Price.*
1702	Smithsonian Miscellaneous Collections (*Quarterly Issue,* Vol. III), Vol. XLVIII. 1907	M.C. XLVIII	
1703	Smithsonian Miscellaneous Collections (*Quarterly Issue*), Vol. IV, Part 1 (containing Nos. 1704–1716). 1907	M.C. L	.50
1704	Dall, W. H. Notes on some Upper Cretaceous Volutidæ, with descriptions of new species and a revision of the groups to which they belong. (*Quarterly Issue.*) 1907	M.C. L	.10
1705	Lyon, M. W., Jr. Notes on some squirrels of the *Sciurus hippurus* group, with descriptions of two new species. (*Quarterly Issue.*) 1907	M.C. L	.05
1706	Stejneger, Leonhard. A new Calamarine snake from the Philippine Islands. (*Quarterly Issue.*) 1907	M.C. L	.05
1707	Rose, J. N. Additional notes on Mexican plants of the genus Ribes. (*Quarterly Issue.*) 1907	M.C. L	.05
1708	Rose, J. N., and Painter, Joseph H. Morkillia, a new name for the genus Chitonia; with description of a new species. (*Quarterly Issue.*) 1907	M.C. L	.05
1709	Andrews, Edward M. The "Webster" ruin in Southern Rhodesia, Africa. (*Quarterly Issue.*) 1907	M.C. L	.10
1710	Cook, W. A. The Bororó Indians of Matto Grosso, Brazil. (*Quarterly Issue.*) 1907	M.C. L	.10
1711	Rose, J. N. Cactus Maxonii, A new cactus from Guatemala. (*Quarterly Issue.*) 1907	M.C. L	.05
1712	Walter, Leo. On the clasping organs attaching the hind to the fore wings in Hymenoptera. (*Quarterly Issue.*) Hodgkins Fund. 1907	M.C. L	.10
1713	Lyon, M. W., Jr. Notes on mammals collected at Mt. Rainier, Washington. (*Quarterly Issue.*) 1907.	M.C. L	.05
1714	White, C. A. The Archaic monetary terms of the United States. (*Quarterly Issue.*) 1907	M.C. L	.10
1715	Knowlton, F. H. Description of a collection of Kootanie plants from the Great Falls coal field of Montana. (*Quarterly Issue.*) 1907	M.C. L	.05
1716	Notes to *Quarterly Issue,* Vol. IV, Part 1.		

VOL. 50 1907

SMITHSONIAN

MISCELLANEOUS COLLECTIONS

VOL IV QUARTERLY ISSUE PART 2

NOTES ON A SMALL COLLECTION OF MAMMALS FROM THE PROVINCE OF KAN-SU, CHINA

By MARCUS WARD LYON, Jr.

Assistant Curator, Division of Mammals, U. S. National Museum

Mr. W. W. Simpson, of Taocheo, province of Kan-su, northwestern China, has recently sent to the U. S. National Museum a small but interesting collection of mammals, and among them are two new species. The general region of northwestern China had previously been entirely unrepresented, so far as mammals are concerned, in the Museum collection. In addition to the specimens listed below, a very young spotted fawn of a rather large deer was collected.

Mr. Simpson also sent to the Museum a photograph from a freshly killed specimen of what is apparently the rare goat antelope *Nemorrhædus argyrochætus* (Heude), shot by Mr. W. N. Ruhl in the fall of 1906. Unfortunately no part of the animal was saved. This photograph is reproduced on plate XVI.

PETAURISTA XANTHOTIS (Milne Edwards)

1868–1874. *P[teromys] xanthotis* Milne Edwards, Recherches Mammifères, p. 301.

The skin and skull of a large flying-squirrel may be referred to this species. Milne Edwards considered his tentative *Pteromys xanthotis* as identical with his *P. melanopterus*. The animal sent by Mr. Simpson, however, differs from the description of *P. melanopterus* in almost precisely the same manner that *P. xanthotis* is said to differ. The skull of the present specimen is much larger and heavier than Milne Edwards' natural size illustrations (Recherches Mammifères, pl. 15*a*, fig. 2) of *P. melanopterus*. I cannot believe that this difference is due to age, for while the Taocheo skull is fully adult, it is not that of an old individual.

External measurements in the flesh, taken by the collector (Cat. No. 144,021, U. S. N. M.): Total length, 780 mm.; tail vertebræ, 350; hind foot, 80. Cranial measurements: Greatest length, 71.5 mm.; zygomatic breadth, 48.5; basal length, 62.4; basilar length, 59; maxillary tooth-row, 18; mandibular tooth-row, 18.6.

MARMOTA ROBUSTA (Milne Edwards)

1870. *Arctomys robustus* MILNE EDWARDS, Nouvelles Archives du Muséum, VII, Bull., p. 92.

1868–1874. *Arctomys robustus* MILNE EDWARDS, Recherches Mammifères, p. 309, pl. XLVII, pl. XLIX, fig. 2.

Seven marmots, two adults and five half-grown young, collected by Mr. Simpson, seem to be identical with *Arctomys robustus* Milne Edwards. The adults are in worn pelage and the black about the head is less conspicuous than indicated in the original descriptions, while the black on the end of the tail has changed to dull reddish brown. In the young specimens the tails are black-tipped. The skulls of the two adults agree in all essential respects with the illustrations of the skull of the type of *Marmota robusta,* the only noticeable differences being the rather longer and wider nasals and longer sagittal crests in the two Taocheo skulls.

External measurements, made in the flesh by the collector, of the two adults, males (Cat. Nos. 144,038 and 144,039 respectively): Total length, 645 mm., 657 mm.; tail vertebræ, 162, 145; hind foot, 102, 92. Cranial measurements of the same two specimens respectively: Greatest length, 103 mm., 103.5 mm.; greatest width, 65, 64.5; basal length, 96.5, 98; maxillary tooth-row (alveoli), 25.6, 25; mandibular tooth-row (alveoli), 23.6, 23.5.

MUS NORVEGICUS Erxleben

Five specimens of the common house rat, an adult and four young of varying ages, were secured by Mr. Simpson. He fails to state whether they were taken in houses or in the open.

MYOTALPA CANSUS, new species

Type.—Skin and skull of adult female, Cat. No. 144,022, collected at Taocheo, Kan-su, northwestern China, May 7, 1906, by W. W. Simpson. Original number, 7.

Diagnostic characters.—Similar to *Myotalpa fontanierii* (Milne Edwards),[1] but nasals much broader anteriorly, zygomata more spreading, and claws of second and fourth manal digits practically equal in length (in *M. fontanierii* claw of second manal digit is distinctly longer than that of fourth).

Color.—Base of fur everywhere slate color, the hairs usually with light ochraceous-buff or dull pinkish buff terminal or subterminal bands, especially on the upper parts of the body, where the mixture of ochraceous-buff and slate produces a general effect not unlike clay color. On the underparts the slate bases of the hairs are more conspicuous than the ochraceous-buff tips. On the throat and chin there are practically no ochraceous tips, and the slate color is rather lighter than elsewhere. The light markings on the head so conspicuously shown in Milne Edwards' plate of *Myotalpa fontanierii* (Recherches Mammifères, pl. 7) are practically absent in *M. cansus.* Just above the naked nose area there is an ill-defined light buffy patch, becoming grayish between the eyes, and thence blending in with the color of the upperparts. Tail nearly naked, clothed with a few scant whitish hairs. Dorsal surface of hind feet practically naked, containing a few short light-colored hairs. Dorsal surface of fore feet covered with short dark-grayish hairs.

Feet.—Fore foot with five digits; the first very short, laterally compressed, and with a much laterally compressed claw, 3 mm. long; second digit with a long, slender, curved claw, 11.5 mm.; third digit with long and rather heavy claw, 14 mm.; fourth digit with claw equal in length to that of second digit, but much heavier, nearly as thick as claw on third digit; claw on fifth digit 7 mm. in length. Hind foot with five digits, the first small and short, with 3 mm. claw; second digit short and stout, claw 5 mm.; third and fourth digits subequal in size, claws respectively 7.5 mm. and 7 mm.; fifth digit small, intermediate in size between first and second, its claw 4.5 mm.

Ears.—The ears are reduced to a mere ridge about 1 mm. high, around a meatus about 4 mm. in diameter.

Skull and teeth.—The skull closely resembles that of *Myotalpa fontanierii* in general form and size. Apparently it is much more angular and with more prominent ridges, characters, however, which may be the result of age. The zygomata are more bowed outward than they are in *M. fontanierii,* and the nasal bones have a peculiar

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[1] Ann. des Sci. Nat., 5th ser., VII, 1867, p. 376, and Recherches Mammifères, pp. 122–126, plate 7, figs. 1–4, plate 8, figs. 6–9 and 13, plate 9, figs. 5 and 8.

terminal expansion and subterminal contraction, better shown in figure 5, plate XV, than described. The enamel pattern of the teeth does not differ from that of *M. fontanierii,* illustrated by Milne Edwards.

Measurements.—Field measurements taken in flesh by the collector: Total length, 260 mm.; tail, 55; hind foot, 36. Cranial measurements of the type: Greatest length, 47 mm.; greatest width, 34; basal length, 44.8; basilar length, 38; interorbital constriction, 6.4; maxillary tooth-row (crowns), 10.3; mandibular tooth-row (crowns), 10.9.

Specimens examined.—One adult, the type, and four half-grown young, all from Taocheo.

Remarks.—Although closely related to *Myotalpa fontanierii, M. cansus,* with its differently shaped nasal bones and claws, is a well marked form. The different tooth patterns for members of the genus *Myotalpa,* as illustrated by Milne Edwards, seem to me to be of more than specific value. It is probable that when the fauna of Asia is better known *Myotalpa* will be found to contain two or more groups of species that may be regarded as subgenera.

OCHOTONA CANSUS, new species

Type.—Adult male, skin and skull, Cat. No. 144,030, U. S. N. M.; collected at Taocheo, Kan-su, China, June 8, 1906, by W. W. Simpson. Original number, 13.

Diagnostic characters.—Closely allied to *Ochotona tibetana* (Milne Edwards),[1] but smaller and zygomatic width of skull considerably narrower.

Color.—General color of upperparts and sides wood-brown, irregularly lined or grizzled with blackish. Behind each ear and toward the back is an ill-defined light spot. On the sides of neck the wood-brown is tinged with cinnamon. Underparts grayish, like No. 9 gray, Ridgway, tinged along the median line and on throat with dull ochraceous-buff. Upper surfaces of fore and hind feet dull cream buff. Base of fur of upperparts slate black; of underparts, slate color. Soles of fore and hind feet densely clothed with light, dirty-brownish hairs.

Skull and teeth.—(Plate XV, figs. 1–3). The skull and teeth are in general similar to those of *Ochotona tibetana,* but evidently

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[1] Nouvelles Archives du Musèum, VII, Bull., p. 93, and Recherches Mammifères, p. 314, pl. XLVIII, and pl. XLIX, fig. 1.

smaller, zygomatic width distinctly less, and audital bullæ larger and the depression of the cranium between cerebrum and cerebellum more pronounced.

Measurements.—External measurements of the type and an adult female (Cat. No. 144,029, U. S. N. M.), taken in the flesh by collector: Head and body, 152, 161 mm.; hind foot, 25, 26; ear from crown, measured from dry skin by writer, 13, 14. Cranial measurements of the type and Cat. No. 144,029: Greatest length, 36.6, 34.3; zygomatic width, 16.4, 16.1; basal length, 30.3, 29.5; maxillary tooth-row (alveoli), 7, 6.9; mandibular tooth-row (alveoli), 7.2, 6.8.

Specimens examined.—Four adults and three young.

Remarks.—Although I have been unable to compare *Ochotona cansus* directly with *O. tibetana,* an examination of the natural size figure of the skull of the latter shows the two forms to be distinct. The differences are too great to be accounted for by inaccuracy in drawing. The length of hind foot in *O. tibetanus* is given as 31 mm., while in *O. cansus* it is only 25–26 mm. I fail to understand, however, why the total length of *O. tibetanus* is only 134 mm., while that of *O. cansus* is between 150 and 160. It may possibly be accounted for by Milne Edwards' measurement being taken from a specimen in alcohol. The account of *Ochotona hodgsoni* (Blyth) given by Bonhote[1] shows that animal to be larger, reddish brown instead of wood-brown in color, and upper surfaces of feet rufous instead of buffy.

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[1] Proc. Zoöl. Soc., London, 1904, II, p. 218.

EXPLANATION OF PLATES

PLATE XV

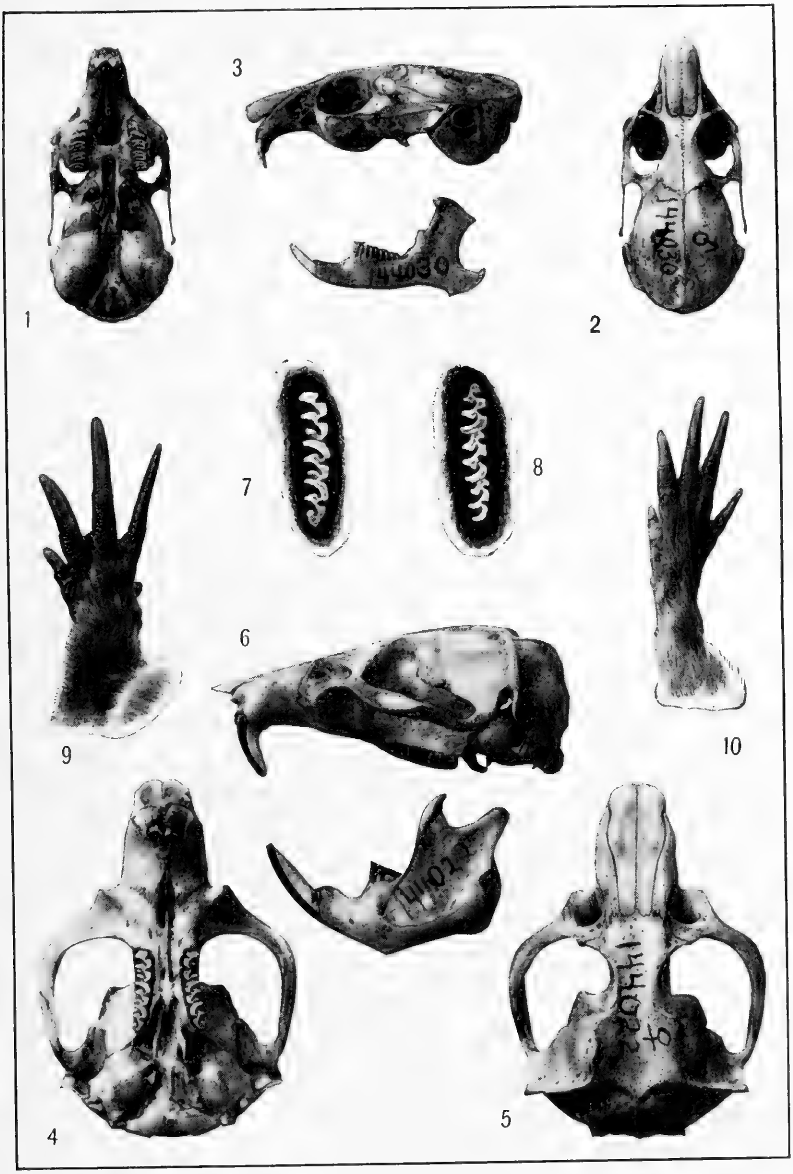
All figures natural size except 7 and 8, which are enlarged about one and three-fourths.

FIG. 1. Ventral view of skull of *Ochotona cansus*, Cat. No. 144,030, U. S. N. M., type, from Taocheo, province of Kan-su, China.

2. Dorsal view of same.
3. Lateral view of same.
4. Ventral view of skull of *Myotalpa cansus*, Cat. No. 144,022, U. S. N. M., type, from Taocheo, province of Kan-su, China.
5. Dorsal view of same.
6. Lateral view of same.
7. Enlarged view of right upper molar series of same.
8. Enlarged view of right lower molar series.
9. Left fore foot of same.
10. Left hind foot of same.

PLATE XVI

Nemorrhædus argyrochætus (Heude), shot by W. N. Ruhl, near Taocheo, China, in fall of 1906.



MAMMALS FROM KAN-SU, CHINA

For explanation see page 138

GOAT ANTELOPE, KAN-SU, CHINA

For explanation see page 138

DESCRIPTIONS OF NEW SPECIES OF SHELLS, CHIEFLY BUCCINIDÆ, FROM THE DREDGINGS OF THE U. S. S. "ALBATROSS" DURING 1906, IN THE NORTHWESTERN PACIFIC, BERING, OKHOTSK, AND JAPANESE SEAS

By WILLIAM HEALEY DALL

The waters described in the title of this paper are certainly the metropolis of the mollusks related to *Buccinum, Chrysodomus,* and *Volutopsius,* and from recent investigations appear to have been so since Eocene times. No other part of the world can compare with this region for the number of species indigenous to it. The latest monograph of the genus *Buccinum* includes 71 nominal species, of which 36, or one-half, are from the North Pacific region, while 35 are known from the whole of the rest of the world. To this 36, 24 are added in the present paper, making 60 in all, which by no means exhausts the fauna, since at least half a dozen other species have been added to the list since the publication of the monograph by Kobelt above alluded to. The richness in the subfamily *Chrysodominæ* is probably quite as great.

There are about fifteen arctic species of *Buccinum* which are circumpolar in distribution which have not been counted in the above enumeration. Of these nine also occur in Bering Sea and vicinity, making a total known *Buccinum* population of about 75 species.

The common European species, *B. undatum* and *Chrysodomus antiquus,* do not appear at all on the Pacific side, though related forms have frequently erroneously been so named by hasty authors.

No doubt the collection made in 1906, when thoroughly studied, will add still more to this series, for more than half the jars have not yet been examined at all. The presence in the Okhotsk Sea of a large number of local species was rather unexpected, as the conditions are strictly arctic in this sea for the most part.

It is noticed that many of the species of the east side of Bering Sea have not yet turned up in the collection, and also that those which do occur on the Asiatic side attain a larger size than any of the same species yet dredged on the American coast.

Illustrations are in preparation and a final report will include the previously known species and many details which are withheld for the present.

Genus PLEUROTOMELLA Verrill

PLEUROTOMELLA SIMPLICISSIMA Dall, n. sp.

Shell small for the genus, smooth, polished, pale straw-color over a chalky substratum, with about six whorls; nucleus eroded, subsequent whorls turriculate with an angular shoulder; suture distinct, not appressed, the whorl in front of it to the shoulder flat, below the shoulder moderately rounded; incremental lines visible but feeble; under a lens obsolete irregular spiral lines are perceptible, but to the naked eye the shell seems smooth; aperture narrow, the anal sulcus wide and shallow, beginning at the suture and extending to the shoulder, after which the outer lip is roundly arcuate forward, receding later to the canal; aperture milk-white, a slight glaze on the body and pillar; columella short, straight, obliquely truncate in front; canal short, wide, not recurved, outer lip thin, sharp. Lon. of shell, 25; of last whorl, 16; of aperture, 11.5; maximum diameter, 9 mm. Operculum absent.

Station 5050, in 1800 fathoms, northeast of Yesso, Okhotsk Sea, September 29, 1906. U. S. Nat. Mus., 110,442.

A very simple yet pretty form, which is probably a *Pleurotomella.*

Genus BUCCINUM Linné

BUCCINUM STRIATISSIMUM Sowerby

Buccinum striatissimum SOWERBY, Ann. Mag. N. Hist., ser. VII, vol. IV, p. 370, fig. 1, November, 1899.

This fine species is rather abundant in the dredgings, having been obtained on the south coast of Yesso, Tsugaru Strait, the Sea of Japan, and the southwest coast of Korea, in from 50 to 568 fathoms. Until the series was compared I was inclined to suspect that this species was identical with the following one, but a study of the series leads me to conclude that, though extremely similar in surface characters and general appearance, the present species can always be distinguished by its rounder whorls and more deeply constricted sutures. It reaches a length of some 120 and a diameter of 65 mm.

BUCCINUM BAYANI Jousseaume

Tritonium bayani JOUSS., Bull. Soc. Zool. de France, VIII, 1883, pl. X, fig. 5, "Japan."

This species is less common than the former, but was obtained from half a dozen stations in the Sea of Japan, and on the coast of

Korea, in from 42 to 406 fathoms. The maximum dimensions noticed are 125 by 50 mm.

BUCCINUM LEUCOSTOMA Lischke

Buccinum leucostoma LISCHKE, Jap. Meeres Conchyl., III, p. 38, pl. 1, figs. 7, 8, 1875.

This handsome species is also rather frequently obtained, especially in Yeddo Bay and on the eastern shores of Nippon. Its dimensions when full-grown may attain 120 by 50 mm., and it has been dredged from as deep as 129 fathoms. The following form, notwithstanding the great difference in dimensions, except at the aperture, almost exactly reproduces this species.

BUCCINUM ZELOTES Dall, n. sp.

Shell small, slender, acute, solid, with two smooth nuclear and eight turgid, strongly sculptured subsequent whorls; suture strongly constricted but not channeled; spiral sculpture of three strong ridges on the convexity of the whorl, articulated with white and reddish brown, a smaller one between the posterior ridge and the suture and another, anterior, on which the suture is laid; base with one more small ridge; in the interspaces are still smaller tertiary sharply cut threads, which also cover the base, and the whole is microscopically sharply striate; the axial[1] sculpture is composed of small but distinct

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[1] A term for indicating the direction of the sculpture which crosses the whorls in general harmony with the axis of a spiral shell, in contrast with that which follows the coil, has long been needed. The latter is generally and appropriately termed "spiral." The former has been called "transverse," meaning transverse to the line of coil, but not transverse to the axis; and "longitudinal," a term which has also been used as synonymous with "spiral." Both of these terms are ambiguous. "Vertical" has sometimes been used, but when the sculpture in question is sinuous or oblique, it sounds disagreeably like a contradiction in terms. Some years ago I proposed to use the term "axial" for this sculpture, though in many cases it does not mathematically coincide with the axis of revolution; yet it seemed appropriate, brief, and comprehensible. If, however, anything less liable to miscomprehension, and in general more suitable, can be suggested, I shall be glad to adopt it. It should be remembered, in considering the subject, that the axis is not always vertical, and that vertical is an absolute term; vertical sculpture cannot logically be oblique, sinuous, or arcuate, while an axis may be either, as, for instance, in *Streptaxis* or some Eulimas.

For the direction of axial ribbing or other sculpture which is not strictly parallel to a vertical axis, concise terms are also needed to indicate whether the ribs slant forward from the summit of the whorls at the preceding suture, which might be called *protractive,* or backward, for which the term *retractive* might be used. Ribbing at right angles to the suture would naturally be called *paraxial* or vertical, as might be most appropriate to the special case.

threads, with wider interspaces which lirate the spiral ribs, but become feeble or absent on the base; aperture rounded, with a much thickened and reflected creamy white outer lip, more or less modified by the external sculpture; pillar and body with a coating of white enamel, the pillar twisted, the canal short, sharply recurved, making a strong fasciole; throat white. Lon. of shell, 62; last whorl, 30; maximum diameter, 30 mm.

Station 4826, in 114 fathoms, Sea of Japan, July 21, 1906. U. S. Nat. Mus., 110,513.

This shell has the same number of whorls with half the length of *leucostoma,* but a much heavier and differently formed outer lip.

BUCCINUM OPISOPLECTUM Dall, n. sp.

Shell small, elevated, slender, subacute, solid, flesh-colored, more or less variegated with brown and white, with one and a half smooth polished, nuclear and six sculptured subsequent whorls; suture distinct, not deep, the edge of the whorl in front of it gathered into rather irregular, small, short plications; spiral sculpture including two primary ridges near the periphery, with two more on the base, the minor sculpture as in *B. zelotes,* the stronger ridges articulated with brown and white; aperture semilunate, the outer lip callous, white, heavy, reflected; body and pillar with a thin white callus; pillar twisted, thickened at the edge; canal wide, recurved with a strong fasciole. Lon. of shell, 40; of last whorl, 27; of aperture, 20; maximum diameter, 21 mm.

Station 4996, in 86 fathoms, Sea of Japan. U. S. Nat. Mus., 110,514.

Belonging to the group of *leucostoma,* but much smaller and more conical.

BUCCINUM NIPONENSE Dall, n. sp.

Shell thin, elevated, flesh-color, more or less variegated or articulated with purple-brown and white, with an olive-brown, conspicuous periostracum and six moderately rounded whorls; suture distinct, not appressed, the whorl sloping flatly away from it to the shoulder; spiral sculpture on the upper whorls of three or four primary low, rounded ridges, the hindmost forming the shoulder of the whorl; on the last whorl nine or ten more, diminishing toward the canal; between these are smaller secondary threads separated by fine, sharp, narrow grooves which also striate the primary ridges and are crossed by fine sharp, sometimes elevated, incremental lines; aperture slightly patulous, outer lip concavely flexuous behind, somewhat thickened, hardly reflected, white; throat flesh-color or purplish brown; body with a wash of callus; pillar straight; the young sometimes have a small sharp ridge upon it; canal wide, short, recurved, with a well-marked fasciole; operculum pale brown, with subcentral nucleus, small for the size of the shell. Lon. of shell, 57; of last whorl, 37; of aperture, 25; maximum diameter, 25 mm.

Station 5038, on the south coast of Nippon, in 175 fathoms, October 2, 1906; also at station 5049, in 182 fathoms. U. S. Nat. Mus., 110,515.

This is nearest some varieties of *B. polare*, but more elevated, slender, smaller, and differently colored. The ovicapsule is lenticular, solitary, and about 10 mm. in diameter.

BUCCINUM CNISMATUM Dall, n. sp.

Shell small, thin, with about six whorls, rapidly increasing, whitish, with a very thin adherent brown periostracum; suture narrow, deep, almost channeled; spiral sculpture of three progressively diminishing strong, wide, ill-defined ridges, the first forming a shoulder near the periphery, the interspace between it and the next anterior roundly excavated, the second with the suture under it, the third and smallest in the middle of the base; between the suture and the shoulder the slope of the whorl is flattish; the whole surface sharply microscopical spirally striated, with the striæ and intervals more or less fasciculated; aperture subtriangular, the outer lip modified by the sculpture, slightly expanded; throat and body glossy, pillar twisted; canal short, wide, recurved, forming a well-marked fasciole. Lon. of shell, 38; of last whorl, 27; of aperture, 20; maximum diameter, 20 mm.

Station 3331, in Bering Sea, north of Unalaska, in 350 fathoms. U. S. Nat. Mus., 110,518.

The sculpture of this curious shell is quite unique—the primary ridges being neither carinate nor squared, but passing without any demarcation into the slope of the interspaces.

BUCCINUM DIPLODETUM Dall, n. sp.

Shell small, thin, whitish, with a thin olivaceous more or less fibrous periostracum and about six rapidly increasing whorls; spiral sculpture of a narrow, flat-topped, strong keel at the shoulder, frequently another at or a little beyond the periphery, and sometimes two smaller threads, between the suture and the shoulder; secondary sculpture of rather obscure flattish spiral threads with equal or narrower interspaces (but no sharp striation) covering the whole surface; suture distinct, not channeled or appressed; aperture semilunar, outer lip thin, slightly reflected; throat, body, and pillar glossy white; pillar short, straight; canal very short and wide, recurved, with an obscure fasciole; operculum well developed, pale, with the nucleus near the middle of the outer edge. Lon. of shell, 38; of last whorl, 26; of aperture, 17; maximum diameter, 21 mm.

Station 3074, off Sea Lion Rock, coast of Washington, in 877 fathoms. U. S. Nat. Mus., 110,517.

This is a very elegant and rather variable little species.

BUCCINUM EPISTOMIUM Dall, n. sp.

Shell of moderate size, solid, capacious, not constricted at the suture, with about six whorls, covered with a closely adherent smooth, unpolished, yellowish periostracum; apex defective; spiral sculpture of numerous, uniform, flattish spiral threads, with narrower, minutely channeled interspaces, about 3 to a millimeter; spire conic, the edge of the whorl more or less minutely puckered in front of the suture; aperture wide, rounded; throat purplish brown; outer lip very thick, white, somewhat reflected; body and pillar with little or no callus; pillar straight; canal wide, recurved, with a slight fasciole; operculum large, very thin, yellowish. Lon. of shell, 57; of last whorl, 40; of aperture, 28; maximum diameter, 35 mm.

Station 4804, off Cape Rollin, in 229 fathoms. U. S. Nat. Mus., 110,519.

An extremely well-marked and distinct species.

BUCCINUM SIGMATOPLEURA Dall, n. sp.

Shell subconic, narrowly turreted, smooth, with about six whorls; spiral sculpture none; axial sculpture of, on the last whorl, about thirty low, rounded, sigmoid ribs with subequal interspaces, extending from the shoulder to the canal; suture distinct, the whorl in front of it narrowly tabulate, but the outer margin of the tabulation evenly rounded off, outer layer of the shell chalky, eroded; toward the base and aperture the layer beneath is more or less colored with purple-black, which also colors the tops of some of the ribs; aperture white, the outer lip not flexuous, white, callous, hardly reflected; body and pillar with a marked callus; pillar arcuate; canal large, deep, recurved, almost as in *Nassa*, making a strong fasciole with a sharp keel at its hinder edge. Lon. of shell, 60; of last whorl, 41; of aperture, 29; maximum diameter, 30 mm.

Station 4792, off Bering Island, in 72 fathoms. U. S. Nat. Mus., 110,520.

In the regularity and extension of the ribs, the curious coloration of the under layer of the shell, and the keeled siphonal fasciole, this species is unique. All the specimens are decorticated hermit-crab shells, but the species cannot fail to be recognized if found.

BUCCINUM POLIUM Dall, n. sp.

Shell of moderate size, solid, elongate-ovate, subacute, with sharply constricted suture and about six rounded whorls; nucleus eroded; whorls in front of the suture slightly shouldered, strongly axially plicate; on the spire the plicæ form rounded arcuate ribs extending from suture to suture, with about equal interspaces; on the last whorl there are 20 to 22, which mostly become obsolete at or a little in front of the periphery; spiral sculpture of fine, feeble, flattish threads separated by narrow grooves, the threads becoming wider and a little more prominent on the base and canal; the whole is covered with a pale olivaceous gray periostracum, which along the incremental lines, when fresh, is delicately fringed, giving a pubescent aspect to the shell; aperture wholly bluish white, the outer lip slightly thickened and reflected; body with a polished white callus, which also extends along the inner side of the straight pillar; aperture longer than wide; canal short, deep, forming a well-marked fasciole. Lon. of shell, 42; of last whorl, 33; of aperture, 25; maximum diameter of shell, 22; of aperture, 11 mm. Operculum with a subcentral nucleus.

Stations 5011 and 5013, in Aniwa Bay, Sakhalin Island, in 42 and 43 fathoms, September, 1906. U. S. Nat. Mus., 110,523, 110,524.

This has some resemblance to *B. tenue* Gray, but has a different color and pubescent surface; the ribs are larger and less irregular than in *tenue* and the shell is more solid.

BUCCINUM ŒDEMATUM Dall, n. sp.

Shell rather thin, swollen, short-conic, with a greenish gray periostracum, which is smooth and caducous, whorls about seven, usually more or less eroded, with a chalky white substratum; sculpture of (on the penultimate whorl about forty) narrow, sharpish, sigmoid wrinkles, with wider interspaces, obsolete on the base, sparser on the last whorl, and more or less irregular, the whole surface finely, evenly, spirally striated; suture distinct, not deep; aperture milk-white, wide, ample, the outer lip deeply flexuous behind, slightly thickened, and reflected; body with a wash of glossy white callus; pillar very short, obliquely truncate, moderately callous; canal wide, very short, sharply recurved, with a well-marked fasciole. Lon. of shell, ♂, 60; of last whorl, 40; of aperture, 29; maximum diameter of shell, 35 mm.

Deep water in Bering Sea; type specimens from station 3502, near the Pribiloff Islands, in 368 fathoms, mud; bottom temperature, 37° F. U. S. Nat. Mus., 107,016. Operculum large, with sublateral nucleus.

A female specimen, still immature, measures 90 x 50 mm., and the species extends south, in deep water, as far as the coast of Oregon.

BUCCINUM ACUTISPIRATUM Dall, n. sp.

Shell very thin, slender, acute, with a sharply constricted suture and about eight evenly rounded whorls, covered with a very pale, nearly smooth olivaceous periostracum; surface with a few (on the antepenultimate whorl 18) nearly straight axial wrinkles, most evident on the upper part of the spire, though not always present; the spiral sculpture is of fine, flat, more or less wavy, threads having a tendency to pair, the intervals being feeble grooves, this sculpture, as usual, a little stronger toward the canal; aperture bluish white, outer lip thin, slightly expanded; body with a wash of callus; pillar rather long, arcuate, twisted, white, with a short, slightly recurved wide canal and feeble fasciole; operculum gray, with the nucleus subcentral. Lon. of shell, 55; of last whorl, 38; of aperture, 26; maximum diameter of shell, 26 mm.

Station 4982, in the Sea of Japan, in 390 fathoms, September 19, 1906. U. S. Nat. Mus., 110,525.

This belongs to the deep-water group of *Buccina,* which all have certain characters in common and can be distinguished at a glance from any shallow-water forms. The nucleus in the type specimen is unusually well preserved, and is subglobular and somewhat swollen, almost like that of some *Chrysodomus.*

BUCCINUM SURUGONUM Dall, n. sp.

Shell solid, heavy, acute, white, covered with a dehiscent, thin, polished periostracum, and with about seven rapidly increasing whorls; suture distinct, not appressed; whorl in front of the suture flattish, sloping to the shoulder and spirally sculptured with (on the last whorl about 12) sharp narrow, sometimes duplex revolving threads, with wider interspaces between the sutures; there is one strong spiral at the shoulder and another at the periphery, with three or four others less in size, and some still smaller intercalary threads and fine spiral striæ, the latter most prevalent on the last whorl; axial sculpture of sharp, elevated, regularly spaced incremental lines which lirate the spiral sculpture; aperture milk-white; outer lip thickened, reflected, excavated behind; body with a glossy white callus which extends the whole length of the pillar, which is short, obliquely truncate in front; canal wide, shallow, recurved, with a moderate fasciole; operculum gray, with a laterally subcentral nucleus. Lon. of shell, 49; of last whorl, 35; of aperture, 26; maximum diameter of shell, 28 mm.

Station 5067, in Surugo Gulf, south coast of Nippon, Japan, in 29 fathoms. U. S. Nat. Mus., 110,526.

Apparently nearest to *B. polare*, but destitute of axial ribbing and with a more acute spire.

BUCCINUM KADIAKENSE Dall, n. sp.

Shell small, acute, yellowish white, with about six sharply sculptured whorls; suture distinct, not appressed; axial sculpture of (on the last whorl of the type about 12) oblique, rounded, wave-like ribs, with wider interspaces, evanescent beyond the periphery; also of fine, prominent incremental lines; spiral sculpture of more or less alternated, distinct rounded threads, one at the periphery slightly more conspicuous than the others; the threads on the base, as usual, stronger than the others; aperture elongate, narrow, body and pillar callous, white, a slight, oblique ridge on the pillar near its anterior edge; pillar long, straight, white; canal wide, hardly recurved. Lon. of shell, 21; of last whorl, 13.5; of aperture, 9; maximum diameter, 8.5 mm.

Kadiak Island, between tide marks, Alaska. U. S. Nat. Mus., 110,527.

This little species recalls *Buccinum ciliatum* Fabricius in its sculpture, but is much more slender and has a more acute and proportionately longer spire. The aperture is not quite completed, but the nucleus of the operculum is subcentral.

BUCCINUM ANIWANUM Dall, n. sp.

Shell of moderate size, with about six evenly rounded, rapidly increasing whorls; suture distinct, not appressed; spiral sculpture practically the same over the whole surface, consisting of fine, subequal, flattish threads, usually paired and arranged in fasciculi of three pairs; these are crossed with extremely minute, elevated, incremental lines which microscopically reticulate the sculpture, showing strongest in the narrow grooved interspaces; aperture semilunar, outer lip (defective); body with a thin wash of glossy callus; pillar thin, white, its edge in front gyrate and almost pervious; throat white, with a lemon-yellow suffusion; canal wide, deep, producing a weak fasciole; operculum thin, pale, the nucleus nearly central. Lon. of shell, 48; of last whorl, 33; of aperture, 24; maximum diameter, 25 mm.

In Aniwa Bay, at the south end of Sakhalin Island, at station 5012, in 40 fathoms. U. S. Nat. Mus., 110,528.

Remarkable for its minute, fine, sharp, uniform sculpture.

BUCCINUM SAKHALINENSE Dall, n. sp.

Shell small, solid, acute, grayish olive, with about seven rapidly increasing whorls; axial sculpture of (on the penultimate whorl about 15) obliquely arcuate, strong rounded ribs, beginning at the suture and becoming obsolete at or near the periphery, on the last whorl weaker and more irregular; spiral sculpture of numerous close, ill-defined, revolving ridges, of which on the last whorl about six are more conspicuous than the others, but all are sharply minutely spirally grooved, the larger ridges having from three to five grooves each; the whole is crossed by minute, crowded, slightly elevated, distinct incremental lines; aperture white, outer lip slightly expanded; body and pillar with a moderate callus; pillar short, its anterior edge distinctly twisted; canal wide, deep, recurved, forming a strong fasciole, with a low sharp keel at its posterior edge; operculum with the nucleus nearly central. Lon. of shell, 36; of last whorl, 26; of aperture, 20; maximum diameter, 21 mm.

Station 5010, Aniwa Bay, Sakhalin Island, in 21 fathoms. U. S. Nat. Mus., 110,529.

This has somewhat the aspect in miniature of *B. undatum;* it is probable that when the shell is fully mature the outer lip is considerably thickened.

BUCCINUM ECTOMOCYMA Dall, n. sp.

Shell large, thin, acute, olivaceus, with a claret-colored nucleus and about six whorls; suture distinct, almost appressed; in front of it the whorl is, as it were, pinched up into short, irregular, strong waves (about 12 on the last whorl), too irregular in form and direction to be called ribs, usually not reaching the periphery; there are also elevated minute incremental lines at intervals on which the otherwise closely adherent periostracum is slightly produced; spiral sculpture of two or three major spiral ridges, one (sometimes obsolete) at the shoulder, another bordering the base, and a feebler one or two on the base; beside this the whole surface is finely sharply grooved and the corresponding raised interspaces are fasciculated in groups of five or six, separated by somewhat deeper grooves; aperture large, whitish; outer lip defective, body and pillar with a wash of callus; pillar short, straight; canal wide, deep, recurved, forming a strong rounded fasciole. Lon. of shell, 52; of last whorl, 40; of aperture, 28; maximum diameter, 30 mm.

Station 5023, on the east coast of Sakhalin, in 75 fathoms. U. S. Nat. Mus., 110,530.

Perhaps nearest to *B. verkruzeni* Kobelt, but a shorter, wider shell, without the regularly spaced similar ribs and elevated spire of that species.

BUCCINUM BOMBYCINUM Dall, n. sp.

Shell small, bulimoid, polished, livid flesh-color, extremely thin, with a subacute spire, thin, closely adherent periostracum and about six whorls; surface smooth, except for very faint incremental lines and a few, simple, spiral, nearly obsolete lines, which look as if they had been pushed out from the inner side of the whorl with a sharp stylus; shell not constricted at the suture; aperture semilunar, outer lip thin, expanded; throat pinkish, a thin wash of callus on the body; pillar white, thin, obliquely truncate in front, the axis pervious in the adult; canal shallow, wide, slightly recurved, forming a slight fasciole; operculum subcircular, nucleus subcentral. Lon. of shell, 27; of last whorl, 20; of aperture, 15; maximum diameter, 14 mm.

Station 5067, in 29 fathoms, on the east coast of Sakhalin Island, Okhotsk Sea. U. S. Nat. Mus., 110,531.

Allied to *B. hydrophanum* Hancock and others of that group, but smaller and differing in minor details.

BUCCINUM LIMNOIDEUM Dall, n. sp.

Shell thin, elevated, acute, slender, straw-color, with spiral bands of pale purple-brown, most of those on the last whorl narrow and articulated, but probably variable, as in other species, with about eight evenly rounded whorls; nucleus of two whorls, the first blunt and smooth, the second sharply spirally striated; subsequent whorls slightly irregularly puckered in front of the suture, but less so on the last whorl; remaining sculpture microscopic spiral striæ, more or less wavy and reticulated by sharp but microscopic incremental lines; the striation is fasciculated by recurrent deeper grooves, but to the unaided eye the shell appears almost smooth; outer lip thin, sharp; throat whitish, a wash of callus on the body and pillar; columella white, strongly twisted, almost plicate, not pervious; canal short, well defined, recurved, forming a strong fasciole, with a sharp keel at its hinder edge. Lon. of shell, 40; of last whorl, 26; of aperture, 18; maximum diameter, 17 mm.

Station 4808, off Hakodate, Japan, in 47 fathoms. U. S. Nat. Mus., 110,532.

The shell has somewhat the form of a large *Lymnæa* and is hardly more substantial. It belongs to the group of *B. picturatum* Dall.

BUCCINUM SIMULATUM Dall, n. sp.

Shell resembling the last in minor sculpture, but with six or seven obscure ribs on the penultimate whorl, hardly reaching the periphery, three strong spirals on the whorls, the last just above the suture and the fasciculi of the spire elevated until they resemble striated threads; color pale livid brown, without color-bands; whorls eight; outer lip thin, slightly expanded, and in front thickened with a white border; throat brownish; body and pillar glossy, not callous; canal short, wide, recurved, with a strong fasciole with a groove behind it, but no keel. Lon. of shell, 38; of last whorl, 25; of aperture, 17; maximum diameter, 17 mm.

Station 4779, in 54 fathoms, on the Petrel Bank, Bering Sea, June 9, 1906. U. S. Nat. Mus., 110,533.

BUCCINUM BULIMULOIDEUM Dall, n. sp.

Shell small, very thin, with a thin periostracum of a straw-yellow color, distinct suture, subacute spire, and about six whorls; surface apparently smooth, but under the lens showing fine uniform microscopic spiral striation, not fasciculated, but more or less undulate; aperture white, outer lip slightly expanded and thickened; a thin wash of callus on the body; pillar short, twisted, not pervious; canal short, wide, deep, forming a marked fasciole with no keel behind it; when fresh, the periostracum, rising on the incremental lines in microscopic elevated lines, reticulates the sculpture, but this is lost with wear. Lon. of shell about 34; of last whorl, 25; of aperture, 16.5 mm.; maximum diameter, 15 mm.

Station 2853, in 159 fathoms, sand, southeast of Alaska Peninsula. U. S. Nat. Mus., 110,534.

This has very much the aspect of a *Bulimulus*, with the exception of the canal.

BUCCINUM ROSSICUM Dall, n. sp.

Shell large, solid, short-conic, with about six whorls, white, clothed with a dense, thick, reticulated pubescent periostracum of an olivaceous tint; whorls rapidly increasing, with an elevated, small, spiral ridge forming a wide, shallow channel in front of the suture, which is usually more or less eroded; at the shoulder is a similar spiral and sometimes one or two fainter ones in front of it; the remaining sculpture is entirely fine spiral threads with narrower interspaces, crossed by incremental lines, while on both lines and threads the lamellæ of the periostracum project from the surface in a dense velvety coating; aperture milk-white, the body and pillar heavily callosified; outer lip thick, expanded, excavated behind; pillar twisted; canal wide, deep, recurved, forming a very prominent fasciole; operculum large, concave, subcircular, the nucleus subcentral. Lon. of shell, 70; of last whorl, 50; of aperture, 35; maximum diameter, 36 mm.

Station 5011, in Aniwa Bay, southern Sakhalin, in 42 fathoms; U. S. Nat. Mus., 110,535; also in Tsugaru Strait, north Japan, in 300 fathoms. U. S. Nat. Mus., 110,536.

This coarse and heavy shell has the general form of *B. viridum* Dall, of the deep water of the California coast, but has finer minor sculpture, a much coarser periostracum, and is in every way a rougher and more solid species, attaining a larger size. At first sight it suggests an *Ancistrolepis,* but the animal and operculum are truly buccinoid.

BUCCINUM PEMPHIGUS Dall, n. sp.

Shell large, thin, swollen, pale olivaceous, with a smooth periostracum over a white chalky layer underlaid by a flesh-colored substratum, with about seven whorls; suture appressed, the surface of the whorl sloping rapidly away in front of it to a small sharp carina which marks the shoulder of the whorl, beyond which the whorl is globosely rounded; there is no axial sculpture except incremental lines; the spiral sculpture consists of low, flattish threads, more or less alternated in size, a few between the shoulder and periphery somewhat more prominent than the rest, but not elevated, having wide striated interspaces, while those in front of the periphery are smaller, closer, and pretty regularly alternated in three sizes; aperture wide, white, the body pinkish, the anterior end of the pillar suffused with yellow; outer lip thin, slightly expanded and flexuous; body with glaze over the pink substratum; pillar straight, its edge gyrate, completely pervious; canal short, wide, recurved, with a faint fasciole; operculum thin, yellowish, with the nucleus sublateral in the posterior third. Lon. of shell, ♂, 63; of last whorl, 48; of aperture, 37; maximum diameter, 37 mm. The females are somewhat stouter and shorter.

Station 4797, in 682 fathoms, off Dalnoi Point, Kamchatka, June 20, 1906. U. S. Nat. Mus., 110,537.

This fine species belongs to the same general group in the genus as the last, but is strongly contrasted with it in many details.

BUCCINUM OROTUNDUM Dall, n. sp.

Shell acute, short, very wide, of a creamy or pinkish white, covered with a thin dehiscent periostracum, having about six whorls; suture distinct, appressed, with a few small irregular axial plications in front of it, especially on the apical whorls; spiral sculpture of low, fine, sharp, subequal threads, of which a few, especially near the canal, are more prominent, having three or four less prominent ones between them; the interspaces are, as a rule, wider, and are reticulated by incremental lines; aperture wide, patulous, yellowish within; outer lip thin, sharp, expanded, flexuous behind, slightly thickened within; body white, glossy; pillar white, arcuate, with a thin layer of callus; canal wide, deep, recurved, forming a conspicuous fasciole with a wide channel behind it; operculum large, brown, with a subcentral nucleus. Lon. of shell, ♂, 60; of last whorl, 50; of aperture, 39; maximum diameter, 40 mm.

Station 3254, in 46 fathoms, north of Unimak Island, Bering Sea; bottom temperature, 36°.2 F. U. S. Nat. Mus., 110,538.

This belongs to the group of *B. polare*, but is far more expanded and devoid of the strong keels which characterize typical *polare*.

BUCCINUM FUCANUM Dall, n. sp.

Shell small, solid, short-conic; spire acute, with a constricted suture and about seven whorls; color pale brownish over a white chalky substratum; suture not appressed or channeled, with (on the last whorl 21) faint, narrow, low, flexuous plications in front of it, which become obsolete on the periphery; the incremental lines, though almost microscopic, are sharp, close, regular, and elevated, forming a distinct feature of the sculpture; spiral sculpture of small, flat fasciculi of four or five threads each, the fasciculi separated by deeper grooves about half the width of a fasciculus; this sculpture requires a lens to make it out and is quite uniform over the surface; aperture wide, white; outer lip expanded, reflected, and thickened, somewhat excavated behind; body with a thin white callus; pillar short, twisted, not pervious; canal wide, short, recurved, forming a moderately distinct fasciole; operculum thin, the nucleus midlateral or nearly so. Lon. of shell, 45; of last whorl, 34; of aperture, 23; maximum diameter, 27 mm.

Station 3452, in 125 fathoms, Fuca Strait; bottom temperature, 44°.5 Fahrenheit. U. S. Nat. Mus., 130,426.

A pretty little species of the *B. plectrum* group.

BUCCINUM EUGRAMMATUM Dall, n. sp.

Shell acute conic, thin, of a subtranslucent brownish consistency (like *B. castaneum* Dall), with about seven turreted whorls; nucleus smooth, of two whorls; suture distinct, with a wide channel in front of it, due to the first spiral rib; axial sculpture of faint incremental lines; surface with an extremely thin, smooth, dehiscent periostracum; spiral sculpture between the sutures of five or six strong, squarish, prominent, spiral ribs, with slightly narrower channeled interspaces, of which there may be from seven to ten on the last whorl; the posterior rib in many cases is nodulous or beaded, corresponding to little waves which at intervals may cross the sutural channel but do not seem ever to extend beyond the second rib; aperture semilunar, throat and body yellow, pillar and outer lip white; outer lip thickened, expanded, somewhat reflected, undulated by the ends of the ribs; a glaze of callus on the body; pillar straight, not pervious; canal wide, deep, recurved, forming a strong fasciole; operculum small, rounded-triangular, the nucleus near the narrower end. Lon. of type specimen, ♀, 54; of last whorl, 40; of aperture, 28; maximum diameter, 31 mm. A defective specimen measures 69 mm. long and 40 mm. in diameter.

Station 4777, in 52 fathoms, Petrel Bank, Bering Sea. U. S. Nat. Mus., 110,539. Specimens were found occupied by hermit-crabs in 54 fathoms at station 4779, in the same vicinity.

This is the most remarkable species made known for a long time and belongs to the group of *B. castaneum* Dall. The strong, clean-cut, regular spiral ribs, with their deep interspaces, give a very striking aspect to the shell.

In leaving the group it may be mentioned that a magnificent specimen of *B. hertzensteini* Verkruzen, was dredged near the entrance to Avacha Bay, Kamchatka, in 58 fathoms, and a variety of *B. verkruzeni* Kobelt, was obtained in 21 fathoms, in Aniwa Bay, Sakhalin.

Genus CHRYSODOMUS Swainson

CHRYSODOMUS INSULARIS Dall, var. CONSTRICTUS nov.

Shell large, thin, pinkish white or purplish brown, with a suffusion of orange on the pillar and part of the outer lip; whorls seven or more, constricted at the suture, outer lip semicircular, thin; axis pervious; spiral sculpture as in typical *insularis,* but with the major spirals decidedly stronger. Lon. of shell, 173; maximum diameter, 107 mm.

Station 4863, in 260 fathoms, off Korea, July 31, 1906; U. S. Nat. Mus., 110,481; also at stations 4868, in 150 fathoms, off Korea, and 5049, in 182 fathoms, east coast of Nippon.

This form differs from *insularis* proper by its rounded whorls, which do not slope away from in front of the suture, which is emphasized as if constricted, and by its more emphatic spiral sculpture and larger size.

CHRYSODOMUS VARICIFERUS Dall, n. sp.

Shell large, very thin in proportion to its height, with six or more rounded whorls; spire short, conic, apex submammillate, whorls rapidly increasing; sculpture of (on the last whorl about seven) sharp, thin, very prominent varices, but little reflected, though projecting 10 to 12 mm. from the whorl; spiral sculpture, on the apical whorls, of three or four obsolete ridges subequal and distant, the middle one on the periphery, and faint spiral threads over and between them; on the later whorls this is obsolete, and the last whorl often shows no spiral sculpture or only faint indications of any; aperture wide, narrow behind and in front, a thin callus on the body and pillar, the outer lip expanded, sharp; pillar narrow, twisted, with a very prominent siphonal fasciole; canal short, slightly recurved. Lon. of shell, 186; of last whorl, 146; of aperture, 117; maximum diameter, including varices, 118; of aperture, 61 mm.

Station 5021, on the east coast of Sakhalin Island, and various stations in the eastern part of Bering Sea. Type, U. S. Nat. Mus., 110,482.

Most likely to be confounded with the smaller and heavier *C. fornicatus* Gray.

CHRYSODOMUS (PERICOCHLION Schrenck, var?) PARALLELUS Dall, nov.

PILSBRY, Acad. Nat. Sci. Phila., Proc. 1901, p. 391, pl. XX, fig. 23.

This form is more elongate, with the same number of whorls, the channel at the suture is wider, the whorls more tabulate and parallel-sided than the typical *pericochlion* of Schrenck. These differences were observed by Pilsbry, but might have been ascribed to individual variation when known only from two specimens; but, a number of specimens having been obtained from Hirasé and the *Albatross* dredgings, all agree with each other and with Pilsbry's figure in these differences; so that the presumption is strong that a different race or variety is indicated, or possibly a different species. A large specimen exhibits 7 whorls, having lost about two; it measures 138 mm. in length by 48 mm. in greatest width; the maximum length of aperture is 59, its breadth 28 mm. The same dimensions of Schrenck's form are given by him as, respectively, 104, 47, 46, and 28 mm. with 8 to 9 whorls. Type, U. S. Nat. Mus., 170,798, from the east coast of Nippon.

CHRYSODOMUS ADELPHICUS Dall, n. sp.

Shell small, compact, with about eight whorls, with a deep channel 1.5 mm. in width in front of the suture, bordered anteriorly by a rounded ridge; first three or four whorls subequal, the remainder rapidly increasing in width; sculpture of fine spiral striæ, the interspaces hardly raised, the striæ segregated into fasciculi by recurring slightly wider sulci; base with the striæ obsolete and the fasciculi represented by slightly more prominent but feeble spiral ridges; pillar callous, arcuate, twisted, almost pervious; canal elongate, narrow, recurved; outer lip thin, gently concave in the middle; shell brownish cream-color, the aperture white. Lon. of shell, 58; max. lat., 24; lon. of last whorl, 38; of aperture, 30 mm.

U. S. Nat. Mus., 109,247. Yokohama. W. J. Fisher.

This shell was kept for many years in the supposition that it was *C. pericochlion*, but on comparison is easily separable.

CHRYSODOMUS ONCODES Dall, n. sp.

Shell solid, compact, turgid, pale brown, of about six whorls; apex defective; whorls rounded, with suture inconspicuous, in front of it sloping gently, with two or three prominent spiral cords separated by wider spirally threaded interspaces; the middle of the whorls with three prominent spiral ridges, the base with ten or twelve less prominent spirals, all with wider, evenly threaded interspaces; the spiral sculpture crossed only by lines or irregularities of growth; the absence of any marked shoulder to the whorls is conspicuous; aperture semilunar; outer lip moderately thickened, not reflected; pillar and body with a moderate layer of callus; the depth of the throat, the outer lip at the margin, and the pillar tinged with purplish brown, the rest white; pillar slightly tortuous, not pervious; canal very short, wide, slightly recurved, with a moderate fasciole. Lon. of shell (decollate, leaving four whorls), 104; of last whorl, 80; of aperture, 62; maximum diameter of shell, 60; of aperture, 32 mm. The total length was originally about 110 mm.

Station 4804, in 229 fathoms, Okhotsk Sea, June 24, 1906. U. S. Nat. Mus., 111,483.

Remarkable among the species of the *liratus* group, to which it belongs, by the absence of any shoulder to the whorl and the inconspicuous suture.

CHRYSODOMUS EULIMATUS Dall, n. sp.

Shell solid, purple-brown, fusiform, with two rather large, smooth nuclear and five subsequent whorls; suture appressed, distinct, the whorl in front of it somewhat constricted, axial sculpture of eight strong, prominent, rounded ribs conspicuous at the shoulder and on the periphery, but obsolete on the base, somewhat flexuous, the whole surface roughened by low, sharp, slightly elevated incremental lines; spiral sculpture practically uniform over the surface and consisting of major spiral cords less than a millimeter in diameter, rounded, with subequal interspaces and minor intercalary threads, usually one, but on the base often two to each interspace, the whole having a rasplike feeling due to the incremental lines; aperture long and narrow, livid brownish; outer lip sharp, body and pillar with a glaze of callus; pillar long, strongly twisted, not pervious; canal long, rather wide, slightly recurved, with a moderate fasciole; periostracum brownish, much as in *C. liratus* Martyn; operculum rather small, with apical nucleus. Lon. of shell, ♂, 68; of last whorl, 53; of aperture and canal, 43; maximum diameter of shell, 34 mm.

Station 5010, Aniwa Bay, Sakhalin Island, in 21 fathoms. U. S. Nat. Mus., 110,541.

This species has somewhat the general form of *Kellettia kelletti*, but with a proportionately longer canal. The rasplike surface is unique, so far, among the species from the North Pacific region. The specimen is probably immature and may attain a considerably larger size.

CHRYSODOMUS TROCHOIDEUS Dall, n. sp.

Shell small, white, broad, remarkably depressed, with about five whorls; nucleus eroded; subsequent whorls rapidly increasing, suture almost channeled, spiral sculpture of, in front of the suture, three or four small, squarish, revolving ribs, with wider excavated interspaces, then a strong peripheral keel, then six or seven, gradually diminishing on the base and canal, always narrower than the interspaces, with an occasional intercalary thread; spire and base short-conic; aperture wide, outer lip sharp, interior white, smooth; body with a wash of callus; pillar short, strongly twisted, and flaring anteriorly; canal very short, wide, and recurved, with no siphonal fasciole. Lon. of shell, 20; of last whorl, 15; of aperture, 11.5; max. lat. of shell, 14.5; of aperture, 7 mm.

Stations 4972, in 440 fathoms, and 4973, in 600 fathoms, off Yokohama, Japan. U. S. Nat. Mus., 110,494 and 110,495.

A curious, squatty little species, unlike any other.

Subgenus ANCISTROLEPIS Dall

CHRYSODOMUS (ANCISTROLEPIS) UNICUS (Pilsbry)

Buccinum unicum Pilsbry, Proc. Acad. Nat. Sci. Phila., 1905, p. 102.

This species, originally referred to *Buccinum,* is a member of this group of very buccinoid form, but *B. taphrium* Dall, the type of the subgenus *Sulcosinus,* has a light, delicate, small shell with a heavy, reflected, callous margin to the outer lip, and a more buccinoid canal than any of the species yet shown to belong to *Ancistrolepis;* so, until the operculum and its anatomy are known, it seems imprudent to merge *Sulcosinus* with *Ancistrolepis,* though the almost channeled suture is very similar.

CHRYSODOMUS (ANCISTROLEPIS) DAMON Dall, n. sp.

Shell elongate, solid, six-whorled, with almost exactly the same sculpture as *C. unicus,* but much more attenuated and larger; the periostracum is dark brown, originally finely axially lamellose, but when worn appearing smooth or even polished; canal and pillar shorter than the aperture, the canal wide, much recurved; pillar twisted but not pervious, callous, bluish white like the rest of the inside of the aperture. Lon. of shell, 80; of last whorl, 55; of aperture 37; max. lat. of shell, 40; of aperture, 20 mm.

Station 5038, in 175 fathoms, October 2, 1906, on the south coast of Yesso. U. S. Nat. Mus., 110,474.

This shell has an extraordinarily close resemblance in sculpture to *C. unicus,* while differing essentially in form, being related to the latter much as *C. grammatus* is to *C. eucosmius.* The effect of wear upon the appearance of the periostracum is very deceptive; shells which appear when worn to have a polished surface frequently were originally more or less villous.

A specimen of *C.* (*Ancistrolepis*) *magnus* Dall 128 mm. long was dredged at station 5021 in 73 fathoms, east coast of Sakhalin Island, Sea of Okhotsk.

CHRYSODOMUS (ANCISTROLEPIS) HIRASEI (Pilsbry)

Buccinum hirasei Pilsbry, Proc. Acad. Nat. Sci. Phila., 1901, p. 391, pl. xx, fig. 22.

This fine species, originally described from a dead shell under the name *Buccinum hirasei,* is certainly a member of the subgenus of *Chrysodomus,* described by me in 1895 under the name of *Ancistrolepis.* The only difference noted is that the periostracum is smooth instead of villous when worn. This group is now found to be rather numerous in species in the northwestern Pacific, Bering, and Okhotsk seas.

CHRYSODOMUS (ANCISTROLEPIS) GRAMMATUS Dall, n. sp.

Shell large but thin, with about nine subtabulate whorls, sculptured with eight or nine very prominent T-rail-shaped spiral ribs, separated by somewhat wider, deeply channeled interspaces; about five of these spirals show between the sutures on the spire; surface covered with a rather thick, axially striated brown periostracum, underneath which is a thin chalky layer of shell easily eroded; pillar and canal, as in all the group, shorter than the aperture, the pillar twisted and more or less pervious, but little recurved; pillar and body with a conspicuous white callus; aperture wide, squarish, the outer lip crenulate by the sculpture, protracted in front beyond the end of the pillar; throat white, not lirate, but reflecting the external ribbing. Lon. of ♀ shell, 101; of last whorl, 65; of aperture, 40; max. lat. of shell, 53; of aperture, 30 mm.

Station 5032, in 300 fathoms, Tsugaru Strait, September 30, 1906. U. S. Nat. Mus., 110,472.

This recalls *C.* (*A.*) *eucosmius* Dall from Bering Sea, but is much larger, with more prominent sculpture and a less twisted pillar. The operculum is heavy, large, and black, of the typical form, though in the young it is lighter-colored and slightly arcuate. The sculpture recalls that of *Beringius crebricostatus* Dall.

Genus TRITONOFUSUS Beck

TRITONOFUSUS CALAMÆUS Dall, n. sp.

Shell thin, white, covered with a straw-yellow periostracum and having about six well-rounded whorls; suture very distinct; apex eroded, nucleus apparently small; sculpture entirely spiral, of (between the sutures on the penultimate whorl, 12) flattish, low, equal, slightly rounded, spiral ridges, separated by narrower, subequal, channeled interspaces and crossed only by faint incremental lines; aperture milk-white, the body with an eroded polished area, the pillar thick and white, twisted and recurved anteriorly; canal wide, short, with no siphonal fasciole; outer lip thin, slightly reflected. Lon. of shell (tip eroded), 57; of last whorl, 42; of aperture, 32; maximum diameter of shell, 28; of aperture, 14 mm.

Station 4797, in 682 fathoms, Okhotsk Sea, June 20, 1906. U. S. Nat. Mus., 110,478.

Notable for its regular sculpture, cheerful yellow color, and milky-white aperture. The operculum is large and brown in color.

TRITONOFUSUS ESYCHUS Dall, n. sp.

Shell slender, acute, solid, of a pinkish brown color, and about eight moderately convex whorls; apex more or less eroded, acute, the suture not deeply constricted; sculpture of numerous fine, narrow, flattish spiral ridges, with a tendency to pair, separated by narrower, not channeled interspaces; the sculpture is distinct but not strong; there are about 25 spirals on the penultimate whorl, of which perhaps one-third are rendered duplex by a medial groove; aperture ovate, livid pink, the outer lip slightly reflected; pillar slender, strongly twisted, and almost pervious; canal contracted and recurved. Lon. of shell, 52; of last whorl, 33; of aperture, 24; maximum diameter of shell, 21; of aperture, 10 mm.

Stations 4791 and 4792, off Bering Island, June 14, 1906, in 76 and 72 fathoms. U. S. Nat. Mus., 110,479.

A larger but imperfect specimen measures 60 mm.

This form recalls *T. spitsbergensis* Reeve, but has a finer and less elevated sculpture and different color.

Subgenus PLICIFUSUS Dall

TRITONOFUSUS (PLICIFUSUS) POLYPLEURATUS Dall, n. sp.

Shell small, thin, with a smooth polished nucleus and seven or more subsequent strongly ribbed whorls; color pale purplish brown, lighter on the ribs; the latter are numerous (18 on the seventh whorl), narrow, irregularly oblique, with subequal interspaces; spiral sculpture faint, visible only on the earlier part of the spire; whorls evenly rounded, suture distinct; aperture semilunar, pillar white, callous; outer lip simple, slightly expanded; canal defective. Lon. of shell, 29 +; maximum diameter, 12.5 mm.

Station 4996, in 86 fathoms, Sea of Japan. U. S. Nat. Mus., 110,476.

A small, slender shell, with close, prominent, rather irregular, oblique riblets, not stopping abruptly at the edge of the base, as in *T. kroyeri,* which with the same number of whorls would be twice as long.

TRITONOFUSUS (PLICIFUSUS) ELÆODES Dall, n. sp.

Shell slender, acute, with a distinct suture, eight moderately rounded whorls, covered with an axially striated nearly smooth, pale olive-gray periostracum over a white or purplish substratum; apex eroded; subsequent whorls sculptured almost exactly like *Buccinum tenue,* with about (on the penultimate whorl) 16 axial, irregular, low, rounded ribs, with mostly wider interspaces extending irregularly beyond the periphery more or less on to the base; the posterior part of the whorls show a few faint, nearly obsolete, small spiral ridges, but the base is sharply spirally sulcate; aperture semilunar; body and pillar smooth, the pillar twisted, almost pervious; the canal short, wide, strongly recurved; outer lip thin, sharp, possibly a little reflected in the adult. Lon. of shell, 54; of last whorl, 34; of aperture, 25; maximum diameter of shell, 22; of aperture, 11 mm.

Station 5011, in 42 fathoms, September 25, 1906, Aniwa Bay, Sakhalin Island. U. S. Nat. Mus., 110,477.

Recalling the young of *T. kroyeri,* but showing on careful inspection a different color and sculpture.

TRITONOFUSUS (PLICIFUSUS) RHYSSUS Dall, n. sp.

Shell of moderate size, white below a pale olivaceous periostracum; of five or six moderately rounded whorls, the apex defective, the suture very distinct, but not channeled; axial sculpture of faint, somewhat irregular, low, short wrinkles, beginning in front of the suture, more sparse and feeble on the last whorl and disappearing at or near the periphery of the whorls; spiral sculpture of fine, close, sharp, equal striæ, with the wider interspaces rounded, about three to a millimeter, covering the whole surface; aperture semilunar, internally white, a thin callus on the body and pillar; outer lip thin, slightly expanded; pillar straight, its anterior edge a little gyrate; canal short, wide, a little recurved, fasciole inconspicuous. Lon. of shell, 49; of last whorl, 35; of aperture, 25; maximum diameter of shell, 20; of aperture, 10 mm.

Station 5013, in 43 fathoms, September 2, 1906; U. S. Nat. Mus., 110,489; also at station 5011, in 42 fathoms, both stations in Aniwa Bay, Sakhalin Island.

The wrinkling, though not as profuse, and the color of the shell recall those of *Buccinum tenue.*

TRITONOFUSUS (PLICIFUSUS) AURANTIUS Dall, n. sp.

Shell of orange-yellow or salmon-colored understratum, covered with a thin chalky layer under an olive-gray periostracum, usually much eroded, with five or six whorls and a very distinct but not channeled suture; surface with numerous fine flattish close-set threads, with narrower channeled interspaces, about four to a millimeter, covering the whole surface, but a little fainter in front of the suture; aperture ovate, the outer lip thin, concavely flexuous behind, produced in front, the body and throat pale-orange color, the body and pillar with a thin layer of callus; canal short, strongly twisted and recurved, with a moderate fasciole; axis pervious. Lon. of shell, 46; of last whorl, 32; of aperture, 24; max. lat., 22 mm.

Station 4982, in 390 fathoms, Sea of Japan, September 19, 1906. U. S. Nat. Mus., 110,490; also at stations 4828 and 4855, in 163 and 70 fathoms, respectively, near the coast of Korea.

The orange-color, conspicuous by the usual erosion of most of the surface, and the short, strongly recurved canal are characteristic features. What appears to be a variety or closely allied species has a deeply orange-tinted shell, with four whorls, strongly recurved, short canal, but with the spirals about twice as wide as in the type, flat above and with distinctly channeled interspaces in which the incremental lines are strong. Lon. of shell, 20; max. lat., 11 mm.; the last whorl 15 and aperture 11 mm. long.

Station 3279, in 41 fathoms, sand, Bristol Bay, Alaska. U. S. Nat. Mus., 122,664.

This form might take the varietal name of *laticordatus*. It is not uncommon in Bering Sea.

TRITONOFUSUS (PLICIFUSUS) CROCEUS Dall, n. sp.

Shell slender, acute, reddish yellow under a pale olive periostracum, with two swollen nuclear and six subsequent whorls; axial sculpture strongest on the spire, where the penultimate whorl shows about 20 rounded, narrow plications with wider interspaces, fading out beyond the periphery and on the last whorl obsolete or absent; spiral sculpture of fine, rounded, closeset, similar spiral threads, subequal over the whole surface except a narrow margin in front of the suture, where they are more or less obsolete; aperture semilunate, internally brownish, with a salmon-tinted pillar obliquely truncate in front, with a moderately recurved canal, the axis not pervious. Lon. of shell, 39; of last whorl, 25; of aperture, 19; maximum diameter of shell, 15; of aperture, 7 mm.

Station 4982, in 390 fathoms, Sea of Japan, September 19, 1906. U. S. Nat. Mus., 110,491; also at station 5038, in 175 fathoms, south coast of Yesso.

This is a more slender species, with a thinner shell and straighter canal than the preceding, which have no axial riblets. It recalls *T. latericeus* Sars, in a general way, but is a much larger shell.

TRITONOFUSUS (PLICIFUSUS) KROYERI Möller, 1842

Collected with the preceding. This species is characterized by fine continuous spiral striation, extending over the whole shell except where it is replaced on the base and canal by the usual coarser striation. The variety *cretacea* Reeve (as *Buccinum*), is distinguished by the absence of the fine striation on the greater part of the shell, more regular and stronger ribs, and more expanded aperture. It was dredged at stations 4779, 4994, 4795, and 5005, in 47 to 190 fathoms. The young are sometimes purplish brown, with the axial ribs ivory-white, stopping short at the edge of the base, which is sharply spirally grooved, making a very striking-looking shell. The adults usually have the spire much eroded, with about 13 ribs on the penultimate and 15 to 18 on the last whorl, obliquely arcuate, with the concavity on the anterior side.

Genus MOHNIA Friele

MOHNIA MICRA Dall, n. sp.

Shell quite small, acute, slender, greenish olive over a chalky substratum, more or less eroded; whorls five or more, the nucleus eroded, the suture minutely channeled; whorls smooth except for incremental lines, moderately rounded; aperture white, outer lip thin, slightly arcuate; body with a wash of callus; pillar white, twisted, almost pervious; canal moderately produced, twisted, almost pervious; on the back of the canal and base there are a few faint spiral striæ. Lon. of shell, 15; of last whorl, 10.5; of aperture, 7; max. lat. of shell, 7 mm.

Station 4813, in 200 fathoms, off Sado Island, Japan Sea, July 18, 1906. U. S. Nat. Mus., 110,499.

This is the smallest species yet described.

MOHNIA SORDIDA Dall, n. sp.

Shell small, slender, acute, with a strong blackish or brownish periostracum, paler or even greenish white on the base and pillar, with a narrowly channeled suture and about six whorls; nucleus eroded, shell more or less coated with a rusty, earthly deposit; early whorls with a few obsolete spirals, the most prominent one peripheral, but absent from the last whorl, where only obsolete impressed lines and microscopic spiral striation remain; axial sculpture only of incremental lines, concavely arcuate; aperture narrow, outer lip thin, sharp; throat brownish or white, pillar greenish white, with a wash of callus, twisted, recurved, pervious; operculum paucispiral, brownish. Lon. of shell, 27; of last whorl, 18; of aperture, 13; max. lat. of shell, 9 mm.

Station 5032, in 300 fathoms, Tsugaru Strait, Japan, September 30, 1906. U. S. Nat. Mus., 110,496.

MOHNIA CLARKI Dall, n. sp.

Shell small, plump, white, with a light green periostracum, usually much eroded, with about five whorls; apex defective in all the specimens; early whorls with (about eleven) small, arcuate, axial riblets, extending from suture to suture, obsolete or absent on the last whorl, their interspaces wider, shallow; no spiral sculpture; whorls flattish, suture distinct, not appressed; aperture white, body and pillar not callous; pillar twisted, nearly pervious; canal narrow, recurved; outer lip arcuate, thin, simple; operculum paucispiral. Lon. of shell (decollate), 21; of last whorl, 16.5; of aperture, 12 mm. Max. lat. of shell, 10.5 mm.

U. S. Nat. Mus., 110,497; at station 4797, in 682 fathoms, Okhotsk Sea, and 110,498, at station 4815, in 70 fathoms, off Hakodate, Japan.

A very simple, pretty little species which would seem when perfect to have rather a blunt apex, which is, however, eroded in every specimen. Named in honor of Mr. Austin H. Clark of the "Albatross" party.

Genus VOLUTOPSIUS Mörch

VOLUTOPSIUS MIDDENDORFFII Dall, var. EMPHATICUS, nov.

Shell resembling *V. middendorffii* in form, size, and coloration, but heavier, thicker, with the spiral sculpture more emphatic, and broken irregularly by conspicuous incremental lines, so that its course forms a series of minute zigzags. These differences, which seem unimportant when analyzed, affect the general aspect of the shell to a disproportionate extent, so that at a first glance it seems very different. The differences between the type from the eastern part of Bering Sea and these from the west seem to hold good with all the specimens. Lon. of shell, 90; max. lat., 48 mm.

Station 4813, July 18, 1906, in 200 fathoms, Sea of Japan; 4804, June 24, in 229 fathoms Okhotsk Sea, and 4982, September 19, in 390 fathoms, Sea of Japan. U. S. Nat. Mus., 110,486 (types), 110,485, and 110,487.

VOLUTOPSIUS? KENNICOTTI Dall, var. INCISUS, nov.

Shell resembling *V. kennicotti* in nearly all features, but distinguished by the much deeper and sharper minute spiral grooving, which gives to the interspaces the aspect of minute crowded spiral threads; the axial ribs (about fifteen in number) are also notably prominent and strong. Lon. of shell, 75; max. lat., 35 mm.

Station 4779, in 54 fathoms, Bering Sea, June 9, 1906. U. S. Nat. Mus., 110,488.

The specimen is about half grown, but the difference in the sculpture is extreme. It came from the so-called Petrel Bank, in the western part of Bering Sea.

VOLUTOPSIUS LIMATUS Dall, n. sp.

Shell small, fusiform, periostracum milky gray in color over a chalky substratum, with about six turreted whorls, more or less eroded, but with a swollen nucleus and the operculum of *Volutopsius;* whorls plump, flattish in front of the suture, but with no angle or keel at the shoulder; surface with a smooth band near the suture, the remainder with fine spiral striæ; the interspaces flat except on the canal, where they are somewhat rounded, and the sulci widen to channels somewhat narrower than the intervening ridges; aperture elongate, livid purple within, a purple callus on the body, the pillar white; outer lip slightly expanded, simple, sharp; canal wide, recurved, axis not pervious. Lon. of shell, 62; of last whorl, 46; of aperture, 38; max. lat. of shell, 27; of aperture, 13.5 mm.

Station 5038, in 175 fathoms, and 5040, in 269 fathoms, off the south coast of Yesso. U. S. Nat. Mus., 110,493 and 110,492 respectively.

VOLUTOPSIUS SIMPLEX Dall, n. sp.

Shell large, thin, pale brown, with five or six whorls somewhat constricted at the suture; nucleus large, mammillate, of about two whorls; subsequent whorls rather convex, smooth, or marked only by irregularities of growth or incremental lines; profile fusiform, the last whorl largest but not expanded; outer lip arcuate, sharp, slightly thickened but not reflected; body without callus; pillar concave, curved to the right, twisted, short, with hardly a trace of a siphonal fasciole; canal short, wide, not recurved. Lon. of shell, 101; of last whorl, 80; of aperture, 57; maximum diameter of shell, 45; of aperture, 26 mm.

Station 4792, in 72 fathoms, off Bering Island, June 14, 1906. U. S. Nat. Mus., 110,475.

This is larger, thinner, smoother, and with a higher spire than any of the varieties of *V. castaneus* Mörch, which has a more irregular surface. *V. regularis* Dall is much smaller, relatively heavier, more regular, and of a different color.

VOLUTOPSIUS (PYROLOFUSUS) HARPA, var. DEXIUS Dall

Shell resembling the ordinary type, but with stronger and closer spirals and dextrally wound. Lon. of shell, 130 mm., the outer lip defective. ♀.

Station 4779, in 54 fathoms, Petrel Bank, Bering Sea, June 9, 1906. U. S. Nat. Mus., 110,484.

The dextral form of this species has not hitherto been known, though a dextral specimen of the *V.* (*P.*) *deformis* Gray, has been for some years in the national collection from the eastern part of Bering Sea. These dextral specimens are, however, of very great rarity.

Genus LIOMESUS Stimpson

LIOMESUS BISTRIATUS Dall, n. sp.

Shell small for the genus, very thick and solid, flesh-color and yellowish-white, with two smooth polished nuclear and three subsequent moderately inflated whorls, subtabulate at the shoulder; spire short-conic; sculpture of two or three sharply impressed spiral lines at the shoulder and on the base, with numerous almost microscopically fine spiral striæ, with a tendency to form fascicles of four or five each; shell in front of the suture flattish, but the tabulation not bounded by a keel; aperture short, wide; outer lip thick, white, simple, slightly expanded; body with a thin wash of callus; pillar short and thick, white, callous, shorter than the aperture, twisted, not pervious; canal very short, wide, recurved, with flaring edges. Lon. of shell, 18; last whorl, 14; of aperture, 11; max. lat. of shell, 12 mm.

Station 4809, in 207 fathoms, off Hakodate, Japan, July 16, 1906. U. S. Nat. Mus., 110,500.

A very neat, compact, and unique little species, in which it is likely the major incised lines may in some individuals extend over the larger part of the last whorl. Both specimens obtained were dead.

Genus TROPHON Montfort

Subgenus BOREOTROPHON Sars

BOREOTROPHON ELEGANTULUS Dall, n. sp.

Shell thin, pellucid white, with a nebulous brown band in front of the suture, one on the last whorl in front of the periphery and a third on the canal; elongate, acute, slender, the whorls of the spire rotund, looking like the spire of a *Scala;* suture distinct, with two nuclear (eroded) and five subsequent whorls; varices 10 to 12, very thin, sharp, reflected, patulous near the suture, but not coronate or spinose; early whorls with three or four distant obscure, spiral threads which later become obsolete; the surface also finely closely spirally striate; aperture elongate-oval, outer lip thin, reflected; body with a wash of transparent callus, which is continued on the pillar as a thin elevated lamella continuous with the left-hand margin of the rather elongated and recurved canal; siphonal fasciole imbricate; interior of the aperture white, showing the color bands. Lon. of shell, 31.5; of last whorl, 23; of aperture and canal, 18; max. lat. of shell, including varices, 12.5 mm.

Station 4784, in 135 fathoms, off Attu Island, Aleutians, June 11, 1906. U. S. Nat. Mus., 110,501.

A very elegant and delicate species.

Genus METULA Adams

METULA ELONGATA Dall, n. sp.

Shell elongate, slender, cancellate, white, with seven or eight slightly convex whorls, with a minutely channeled suture; apex defective, subsequent whorls minutely regularly wholly cancellated by small flattish axial and spiral threads; the sculpture is a little stronger just in front of the suture and on the canal, elsewhere pracically uniform; aperture long and narrow, with a shallow posterior sulcus; both lips thickened, the outer more or less crenulate; pillar straight; canal short, wide, slightly recurved. Lon. of shell (without the nuclear and apical whorls), 35; of last whorl, 23; of aperture, 16; maximum diameter last whorl, 9.5 mm.

Station 5071, in 57 fathoms, south coast of Nippon, Japan, October 15, 1906. U. S. Nat. Mus., 110,502.

Resembling *M. mitrella* Adams and Reeve, but much larger and of different proportions.

Genus GALEODEA Link (CASSIDARIA Lamarck)

GALEODEA LEUCODOMA Dall, n. sp.

Shell large, thin, white, with a short conical spire, having seven or more whorls; nucleus lost; subsequent whorls with the suture minutely channeled, the whorl in front of it flat, sloping to a shoulder formed by the first of four prominent straplike, prominently nodulous spirals (two of which appear between the sutures on the spire), which are separated by wider interspaces; on the last whorl there are about 25 of these similar and equal nodules; following these four there is a series of about 17 more similar but not nodulous spirals, which gradually decrease in size and approach each other more closely, until they are reduced on the canal to mere threads; beside these the interspaces have numerous smaller subequal spiral threads; all are crossed and faintly reticulated by well-marked incremental lines, which sometimes form wrinkles near the suture; aperture milk-white, the outer lip thickened, strongly reflected, and on the inner edge of the thickening obscurely crenulate; body with a thin coating of callus with a few nodulations near the junction with the outer lip; pillar callous, arcuate, concave, its anterior edge obliquely twisted, forming a pervious axis; canal short, recurved with a short fasciole; operculum brown, ovate, with a paucispiral nucleus surrounded by concentric structure, the nucleus to the right of the center of the anterior third. Lon. of shell, 67; of last whorl, 58; of aperture, 50; of operculum, 25; max. lat. of shell, 50 mm.

Station 4912, in 391 fathoms, August 12, 1906, off Kagoshima, Japan. U. S. Nat. Mus., 110,503.

This fine and elegantly sculptured species is perhaps nearest to the *G. echinophora* of the Mediterranean, from which it is distinguished by numerous characters, the most conspicuous of which, perhaps, is the absence of any raised lamella on the pillar and canal.

Genus ASTRÆA Bolten, 1798 (ASTRALIUM Link, 1807)

ASTRÆA PERSICA Dall, n. sp.

Shell small, conic, whorls overhanging the suture and about five in number; ground color a creamy yellow with radiating flammules of very dark purple, grading off on the anterior side to crimson and rose pink, separate tubercles having dark color giving the effect of dots; early whorls with, on the upper surface, five beaded spirals, between which on the later whorls are intercalated one or more much smaller beaded or simple threads; these are crossed obliquely by small, sharp, imbricated lamellæ, visible only under a lens; at the periphery the thin keel is produced into narrow, guttered spines with two or three radial threads on each; base elegantly flammulate with dark purple, sculptured like the upper side, having one strong nodulous and seven or eight smaller spirals and the same imbricate minor sculpture; the peripheral keel should have, when intact, about 20 spines; umbilical region smoothly covered with a milk-white callus; aperture rounded, the outer lip leading at the suture, which is laid on the prominent basal spiral before mentioned, aperture white except where the color markings show through the glaze. Alt. of shell, 20; maximum diameter, excluding spines, 22; diameter of aperture, 10 mm. The operculum was not preserved.

Station 4936, in 103 fathoms, off Kagoshima Bay, Japan, August 16, 1906. U. S. Nat. Mus., 110,507.

The coloration of this exquisite little shell reminds one of the delicate pattern of a fine Persian rug. The spines when perfect are about 4 mm. long. There is no species noted in the monographs to which it is at all closely allied specifically.

Genus BASILISSA Watson

BASILISSA BABELICA Dall, n. sp.

Shell large, white, acutely conic, with about twelve whorls; apex defective, early whorls convex, with a peripheral row of nodules, which, in successive whorls, descends to the level of the suture which it overhangs, developing into a marked keel, which, at first nodulous, becomes later merely crenate; sides of the whorls, except near the apex, flat; the base almost flat, the whole surface finely and closely spirally striate; incremental lines between the sutures gently concave forward; base compressed at the peripheral keel, within which it is slightly convex to a keel which borders a deep, 5 mm. wide funicular umbilicus with vertically striate walls; incremental lines of the base sweeping forward from the peripheral keel and receding to the umbilical keel; aperture roughly quadrate, with a continuous thin, sharp margin, which exhibits a sulcus corresponding to the umbilical keel and angles at the suture and peripheral keels; the basal margin leads the others when intact; operculum horny, pale yellow, externally concave, with a somewhat ragged periphery and about four whorls. Alt. of shell, 37; of aperture, 8; maximum diameter of shell, 25; of aperture, 12 mm.

Station 4972, in 440 fathoms, and 4973, in 600 fathoms, August 30, 1906, off Yokohama, Japan. U. S. Nat. Mus., 110,504 and 110,505.

This is the largest and most striking species yet described. *B. superba* Watson comes nearest to it, but is much smaller and less attenuated.

In the same cast was obtained *Leptothyra* (*Phanerolepida*) *transenna* Watson, which I separate from the typical Leptothyras on account of the absence of spiral sculpture, the peculiar shagreen-like surface, and the operculum, in which the whorls are not, as in the typical *Leptothyra*, visible externally and flat, but are concealed by a callous deposit and have a concave surface. These features, as such things go, are at least sufficient for sectional distinction.

Genus MICROGAZA Dall

MICROGAZA FULGENS Dall, n. sp.

Shell larger than *M. rotella* Dall, but of much the same general aspect; depressed turbinate, brilliantly polished, very thin, the pearly luster shining through a very thin yellowish periostracum, the upper surface painted with a pale brown zigzag nebulous coloration; nucleus globular of a single whorl, pale, followed by five subsequent whorls moderately convex, with obsolete incremental and spiral markings; periphery rounded, base uniformly pale, the convexity equal to that of the upper surface of the whorl, with a large, completely pervious, vertical-sided umbilicus, with a rectangular margin; the keel of the umbilicus is crenate by short radial grooves, which also extend up the sides of the funnel and are sharply reticulated there by four or five sharp spiral grooves; aperture ample, the upper part of the outer lip produced, making the plane of the aperture oblique; remainder of the margin rounded except at the umbilical keel and where the body interrupts the thin sharp peristome; interior pearly; operculum thin, concave, yellowish, with about eight whorls. Alt. of shell, 6; maximum diameter, 10; minimum diameter, 8 mm.

Sea of Japan, at station 4891, 1906. U. S. Nat. Mus., 110,543.

Genus COCCULINA Dall

COCCULINA JAPONICA Dall, n. sp.

Shell small, white, elevated, finely, sharply, radiately striated, the apex recurved; anterior slope convexly arcuate, longer; posterior slope direct, sloping, shorter; periostracum very thin, pale yellowish; interior smooth, white; margin thin, nearly equally rounded at both ends. Lon. of shell, 8.2; lat., 6; alt., 3.5; the apex behind the anterior end, 7 mm.

Off Sado Island, Sea of Japan, at station 4813. U. S. Nat. Mus., 110,544.

This is the first record of the genus from the Sea of Japan.

Genus DENTALIUM Linné

DENTALIUM CROCINUM Dall, n. sp.

Shell solid, reddish yellow, smooth, polished, without sculpture except incremental lines; diameter rather rapidly increasing; anal aperture entire, circular; also the anterior aperture; shaft arcuate. Lon. of shell (chord), 39; diam., post., 1; ant., 5 mm.

Station 5094, Gulf of Tokio, Japan, in 88 fathoms. U. S. Nat. Mus., 110,508.

This is nearest *D. longistrorsum* Reeve, but increases more rapidly in caliber and probably does not attain so great a length.

Genus NUCULA Lamarck

NUCULA MIRIFICA Dall, n. sp.

Shell olive brown, with a brilliantly polished periostracum, obscurely microscopically radially striate or smooth, with faint concentric incremental irregularities; beaks low and inconspicuous, prosocœlous, very anterior; general outline egg-shaped, the short anterior end obscurely truncate, lunule and escutcheon absent, though there is a slight depression under the beaks without definite limits; interior nacreous white, the margins entire, pallial line and muscular impressions distinct but not deep; hinge line evenly arcuate, divided by a large, obliquely directed chondrophore; teeth of the anterior series crowded, 10 to 11 in number; posterior series with 16 to 17 less crowded prominent teeth. Alt., 26; lon., 36; diam., 16 mm., the vertical of the beaks 6 mm. behind the anterior extremity of the valves.

U. S. S. *Albatross,* station 5040, south coast of Yesso, October 3, 1906, in 269 fathoms. U. S. Nat. Mus., 110,463.

This appears to be the largest smooth and typical *Nucula* yet described, though a specimen of *Acila mirabilis* Adams and Reeve, was obtained at station 4994, in 190 fathoms, which measured 41 mm. long, 29 mm. high, and 22 mm. in diameter.

Genus PECTEN Muller

PECTEN (CHLAMYS) ERYTHROCOMATUS Dall, n. sp.

Shell resembling *P. hericeus* Gould and *P. islandicus* Muller in general appearance, but differing in the following details. Than *islandicus* it is somewhat more rounded in the disk and more convex; the anterior ears are smaller and more vertically truncate distally; the hinge line is shorter and the posterior ears smaller and the byssal fasciole narrower; the radii are smaller, keeled and minutely spinose instead of smooth and flat on top and laterally rounded; the minor reticular sculpture is more oblique and rough, the channels between the radii relatively wider; the radii themselves are gathered obscurely into fascicular bundles, which as a whole are raised like wide obsolete ribs; the colors are obscurely radial, rose-red and white instead of mainly concentrically distributed. Than *hericeus* the hinge-line is more horizontal and the anterior ears much smaller, the byssal fasciole much narrower, the minor sculpture more rasplike, the individual spinules straight distally instead of arcuate, the larger riblike fasciculi very much less distinct, only five or six in number against about 18 in *hericeus;* the interior is less colored. Alt., 69; lon., 70; diameter, 24; lon. of hinge line, 32 mm.

U. S. S. *Albatross,* station 5021, Okhotsk Sea, September 27, 1906, in 73 fathoms. U. S. Nat. Mus., 110,462.

The lower valve is white, but its sculpture similar to that of the upper valve. The station is on the east coast of Sakhalin Island.

Genus CRENELLA Brown

CRENELLA GRISEA Dall, n. sp.

Shell thin, oblique, elongate, rounded-quadrate when adult, the young specimens relatively shorter; surface of a grayish olivaceous color, with lighter and darker zones, brilliantly polished, with faint, irregular traces of fine obsolete radial striation; beaks inconspicuous, hinge line gently arcuate, with a minutely denticulate small lamella directly under the beaks; the margin behind the beaks with narrow internal elongate ligament, behind which are sharp minute interlocking denticulations of the margin, beyond which the margin is minutely crenulate; interior bluish perlaceous; hinge line behind the beaks slightly rounded and produced, but not quite angulate. Longest extension of shell, 12; dimension at right angles to this, 8.5; diameter, 7 mm.

U. S. S. *Albatross,* stations 4782, off east end of Attu Island, June 9, and 4784, June 11, 1906, in 57 and 135 fathoms respectively. U. S. Nat. Mus., 110,464 and 110,465.

Peculiarly shaped and colored, but not identical, as far as can be told, with any of A. Adams' imperfectly described nominal species.

CRENELLA DIAPHANA Dall, n. sp.

Shell large for the genus, tumid, extremely thin, elongate-ovate, pale horn-color, finely minutely radially sculptured, the interspaces channeled distally, but narrower than the radii; beaks prosocoelous, prominent; hinge line very short, the valves nearly equilateral, the sides similar, the base medially produced; internal ligament strong, anteriorly divided, the margins minutely crenulate, but not interlocking, except immediately under the beaks; alt., 18; lon., 14; diameter, 13 mm.

U. S. S. *Albatross,* station 5092, October 26, 1906, in 70 fathoms, Gulf of Tokio. U. S. Nat. Mus., 110,466.

The shell is so equilateral that it looks like the dorsal valve of a delicately sculptured *Terebratulina.*

Genus MODIOLARIA Beck

MODIOLARIA IMPRESSA Dall, n. sp.

Shell small, thin, arcuate, elongate, olive-green or brownish, with a small striate anterior area, deeply impressed middle area, and large, tumid, nearly smooth posterior area; surface polished, beaks very anterior, inconspicuous; anterior area very short, with about six pairs of strong radial riblets; middle area polished, smooth, gaping below for the byssus, where the margin is a little convex, behind which it is conspicuously excavated; posterior area swollen, arcuate above, produced behind and below, dropping vertically to meet the depressed middle area, faintly concentrically and obsoletely minutely radially striated; interior pearly; inner margins crenulate around the distal areas, medially smooth, with a few interlocking denticulations just behind the internal ligament, but none in front of the beaks; byssus strong. Alt., 10; lon., 19; maximum diameter, 9 mm.

U. S. S. *Albatross,* station 4677, June 5, 1906, in 52 fathoms, Bering Sea. U. S. Nat. Mus., 110,467.

Peculiar on account of the strong constriction of the middle areas and the arcuate form.

Genus LIOCYMA Dall

LIOCYMA ANIWANA Dall, n. sp.

Shell small, solid, pale grayish or straw-color, with low, rather anterior beaks; anterior end short, rounded; posterior end longer, attenuated; base evenly arcuate; about two-thirds of the valve with strong concentric waves with subequal interspaces, the remainder concentrically striated; interior bluish white, with the middle of the disk yellowish; pallial sinus very short; hinge normal, heavy. Lon. of shell, 24; alt., 18; diameter, 13 mm. Vertical of the beaks about seven mm. behind the anterior end; the beaks somewhat eroded.

Station 5013, in 43 fathoms, Aniwa Bay, at the south end of Sakhalin Island. U. S. Nat. Mus., 110,511.

Ruder, more inflated and solid, and more attenuated behind than any of the arctic or Aleutian species.

Genus PHOLADOMYA Sowerby

PHOLADOMYA PACIFICA Dall, n. sp.

Shell thin, whitish, more or less minutely granular on the exterior surface, with a very thin pale yellowish periostracum, equivalve, nearly equilateral; form resembling that of *Mya arenaria,* but proportionately more inflated; anterior end rounded, posterior slightly attenuated; hinge-line nearly straight, base arcuate; sculpture of (on the middle of the disk, 10 or 12) rounded, moderately elevated, radial ridges with wider interspaces near the base, but crowded near the beaks; the periostracum near the end of the shell exhibits minute radial wrinkles, but the terminal fourths of the valves are destitute of sculpture except faint concentric irregularities. Interior smooth, slightly pearly, with a shallow rounded pallial sinus and faint muscular scars; basal margins crenulated by the sculpture, thin, sharp; hinge typical, ligament and resilium weak. Lon. of largest valve, 48; of pair, 44; alt., 30; diam., 25 mm.

Station 4807, off Hakodate, in 44 fathoms, and station 4904, in 107 fathoms, near Nagasaki, Japan. U. S. Nat. Mus., 110,545 and 110,456.

This is the first recent species, which has been brought to notice since the description of the Antillean *P. candida* in 1823, except a minute abyssal form from the North Atlantic.

A NEW LARCH FROM ALASKA

By W. F. WIGHT

LARIX ALASKENSIS Wight, sp. nov. Alaska Larch

A small tree, attaining a maximum height of about 9 m. and a diameter of 20 cm.; leaf-fascicles at the ends of branches 3 to 5 mm. long; leaves pale green, 5 to 20 mm. long, about 5 mm. broad, rounded on the upper surface, slightly keeled on the lower; cones borne at the ends of lateral branchlets 3 to 5 mm. long, ovoid or short-oblong, 10 to 15 mm. long, 9 to 12 mm. broad; cone scales slightly longer than broad, the larger ones 8 to 10 mm. long, 7 to 9 mm. broad, rounded at the apex, abruptly contracted toward the base; bracts of the cone about one-third as long as the cone scales, ovate, acute; flowers not seen.

Distribution.—Upper Kuskokwim River to the Yukon and Tanana rivers.

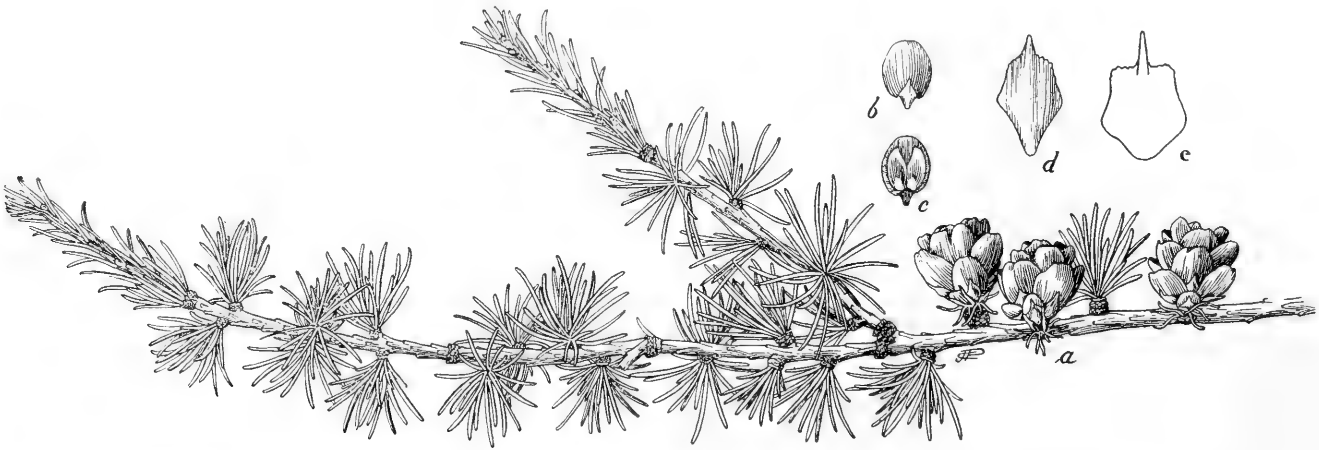
Type-specimen: No. 379,803, U. S. Nat. Mus.; collected August 6, 1902, at Tanana, Alaska, by A. J. Collier (no. 117).

Larix alaskensis differs from *L. laricina* in its usually shorter leaves, but more particularly in its cones. The cone scales are longer in proportion to their breadth; the bracts of the cone scales are ovate and without a projecting mucronate point at the apex, while *L. laricina* has bracts short-oblong to nearly orbicular in outline, and commonly emarginate or lacerate on either side of a mucronate projection at the apex. From *L. dahurica,* the most closely related Asiatic species, it differs in its usually shorter leaves, in its smaller cones, with the cone scales less widely spreading in dried specimens, and in its narrower cone bracts.

Between the Yukon and Cook Inlet.—Upper Kuskokwim, Herron, August, 1899; Tanana Valley, east of Cantwell River, Brooks & Prindle, August 27, 1902; Kaltag, on the Yukon, Collier, 1902 (no. 147); Tanana, Collier, 1902 (nos. 117, 118); Weare, Georgeson, 1900 (no. 6).

EXPLANATION OF PLATE XVII

a. Fruiting branch.
b. Back of cone scale.
c. Cone scale, with ovules.
d. Bract of cone scale.
e. Bract of cone scale of *L. laricina.*



LARIX ALASKENSIS WIGHT, SP. NOV. ALASKA LARCH

THE LUMPSUCKER; ITS RELATIONSHIP AND HABITS

By THEODORE GILL

One of the most interesting of fishes from several points of view is the common Lumpsucker of the North Atlantic. Its skeleton is cartilaginous to such an extent that it was ranked by the old naturalists with the cartilaginous fishes; by later naturalists, although referred to the bony fishes, it was associated with forms subsequently found to be in no wise related, and not until quite recently has its true relationship been discovered and proved; it exemplifies a certain phase of retrograde development. It is at once the type of a peculiar genus (*Cyclopterus*) and a very distinct family (*Cyclopterids*).

I

The Cyclopterids, or Lumpsuckers, have a short, swollen, oviform body, large abdominal cavity, a circular sucker formed by the united

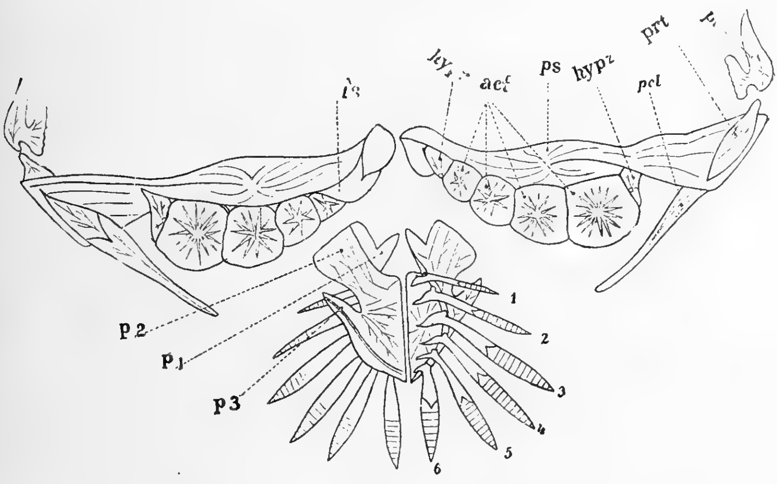


FIG. 32.—Skeleton.—Scapular arch and pelvis of the Lumpfish, the right-hand figures representing the external surface, the left-hand figures the internal surface of those bones. After Borckert.

a, actinosts 1–4.
hypr, hypercoracoid.
hypo, hypocoracoid.
is, interscapula.
p1, Anterior pointed process.
p2, Anterior broad process.
p3, lateral process.
pcl, postclavicle.
prt, posterotemporal.
pt, posttemporal.
ps, proscapula (cœnosteon).
1–6, ventral rays.

ventrals, a short anal, generally a short, soft dorsal, and, typically, a more or less distinct spinous dorsal, but sometimes none at all.

Such are the chief superficial characters common to all the species; but if we would appreciate the distinctness of the family, we must examine the skeleton. The species are few, but the differences between them great. All those that are certainly known are confined to the cold northern seas and most of them to the high Pacific Ocean or Bering Sea. The two best known, however, are inhabitants of the North Atlantic; one of these, the name-giving member of the family, is familiar to all frequenters of the high northern waters; the other, *Eumicrotremus spinosus,* is a more northern form, beyond the ken of most civilized men, and, being a small and deep-living form, has received no popular name.

A peculiar characteristic of the Cyclopterids, and especially of the common Lumpsucker, is the extreme reduction of the osseous elements and the inverse development of the cartilaginous skeleton. The extent of the cartilage is such that a skeleton cannot be made, or at least kept, like that of an ordinary fish, but shrinks and becomes distorted and shriveled up. All the bones, however, are there, but existent in a reduced state or as thin membrane-like pieces fastened to the cartilaginous mass. On account of this condition of the skeleton, the old writers on ichthyology were greatly misled as to the relationship of the fish, and Linnæus, in his classification, ranged the fish with the sharks, rays, sturgeons, and some others in a group which he called the order Chondropterygii. It has, however, not the slightest affinity with any of those fishes, but is really most nearly related to the Sculpins or Cottids, which have the bones firm and well ossified and very little persistent cartilage.[1] Like them, nevertheless, the Lumpsuckers have the second suborbital bone after the preorbital broad and obliquely prolonged to the inner margin of the preopercle to connect as a stay with the latter. Coördinate with this structure are numerous modifications of the skeleton which essentially resemble corresponding ones of the Cottids. Especially noteworthy are the characteristics of the bases of the pectoral fins. (See fig. 32.)

II

The species of Cyclopterids are few, but so distinct that there are almost as many genera as species. Only eleven species are definitely

[1] The characteristics and affinities of the Lumpsuckers have been considered by the present writer in an article "on the relations of the Cyclopteroidea," in the Proceedings of the U. S. National Museum for 1890 (XIII, 361–376, pls. 28–30).

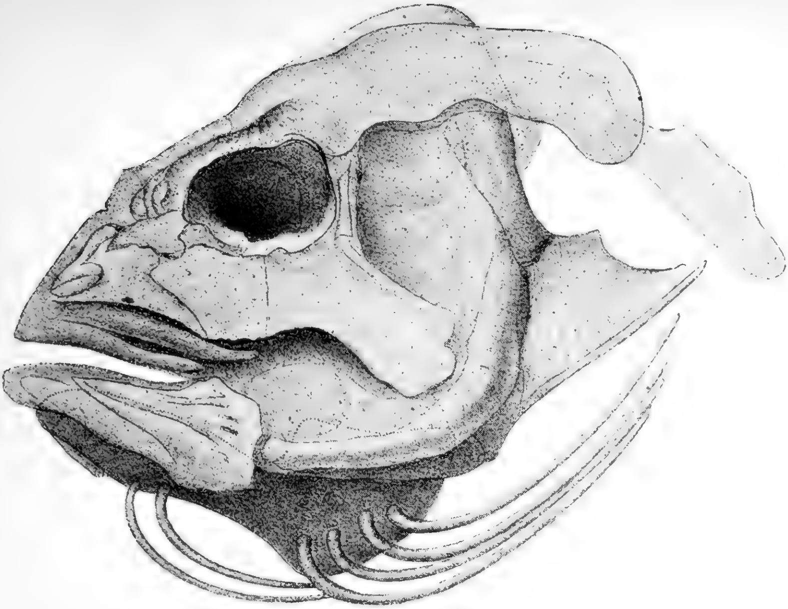


FIG. 33.—Skull of Lumpfish, second suborbital developed as a stay (Garman).

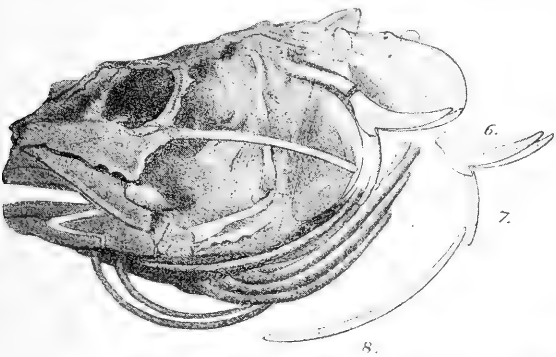


FIG. 34.—Skull of *Liparis,* for comparison with that of Lumpfish (Garman).

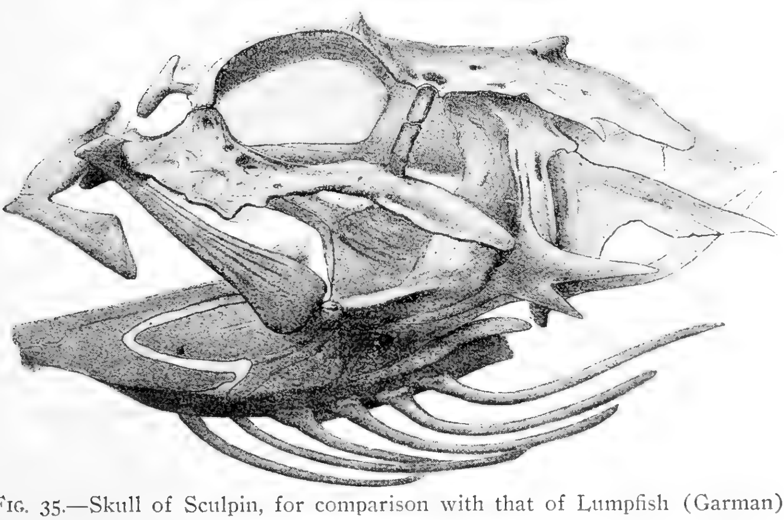


FIG. 35.—Skull of Sculpin, for comparison with that of Lumpfish (Garman).

known, but they are so greatly differentiated that no less than six genera have been provided for them; four of these genera include or are more or less closely related to the common Lumpfish and combined in one subfamily (*Cyclopterinæ*) contrasted with another (*Liparopinæ*) including the other two genera.

The CYCLOPTERINÆ have a well-defined spinous dorsal, although in the adults of the common Lumpfish it is overgrown by the skin and tubercles. The subfamily includes four genera which are superficially distinguishable by the following characters:

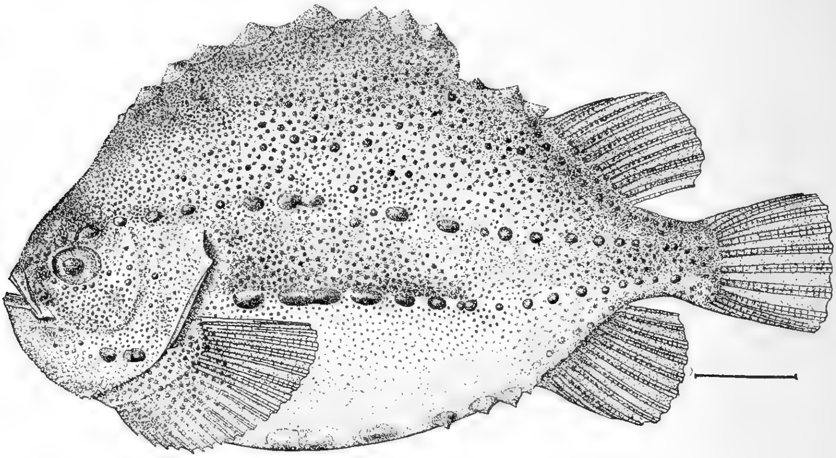


FIG. 36.—Common Lumpfish or Lumpsucker, *Cyclopterus lumpus*. After Goode.

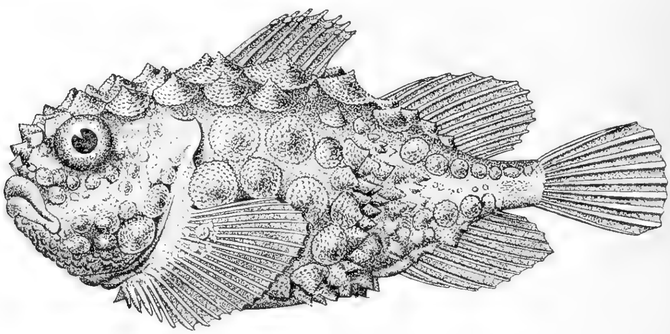


FIG. 37.—*Eumicrotremus spinosus*. After Collett.

Cyclopterus has large tubercles well separated, but arranged in seven regular longitudinal rows, and the first dorsal becomes overgrown and lost to view with maturity. The branchial apertures are moderate. The *Cyclopterus lumpus* is the only recognized species.

Eumicrotremus has large tubercles closely but irregularly arranged, and the first dorsal remains developed through life. The branchial apertures are much reduced. Four species are known, the *E. spinosus* of the arctic Atlantic and the *E. orbis, E. pacificus,* and *E. brashnikowi* of the northern Pacific.

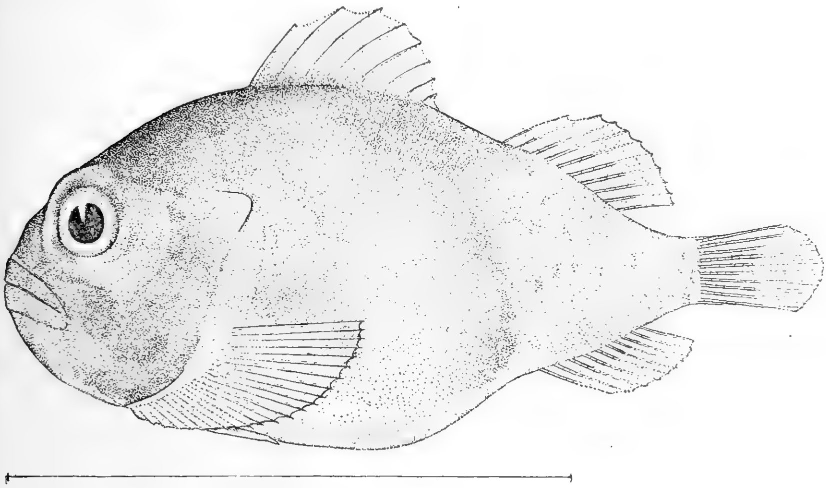


FIG. 38.—*Lethotremus muticus.* After Jordan and Gilbert.

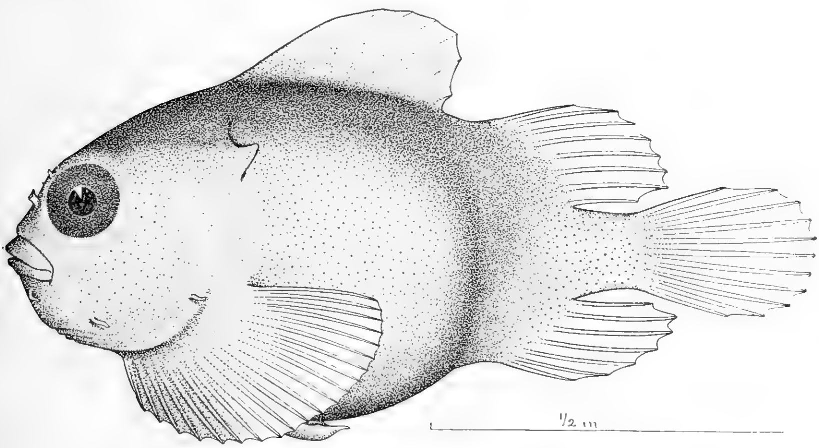


FIG. 39.—*Lethotremus awæ.* After Jordan and Starks.

Lethotremus has no large tubercles, the skin being naked or with few scattered spinules, and the first dorsal is well developed and sustained by 6–8 slender spines. The branchial apertures are very much reduced. Two species are known from the North Pacific, *L. muticus and L. awæ.*[1]

FIG. 40.—*Lethotremus vinolentus.* After Jordan and Starks.

Cyclopteroides has small spinigerous tubercles well separated, but arranged in eight regular longitudinal rows and the two dorsals are partly enveloped in the skin; the ventral disk is abdominal and further back than in the other genera. The only species (*C. gyrinops*) has been found in Alaskan waters.

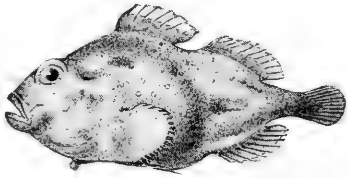


FIG. 41.—*Cyclopteroides gyrinops.* After Garman.

The LIPAROPINÆ have no external spinous dorsal, the back in front of the soft dorsal being completely finless. Two genera have been distinguished.

[1] Another species has been added to *Lethotremus* as *L. vinolentus* by Jordan and Starks. It differs apparently in physiognomy as well as by the development of the fins and the presence of scattered spinous tubercles on the head and fore part of the body; it is scarcely a natural associate of the other species, and doubtless Jordan and Starks may hereafter distinguish it generically. The only known specimen was in poor condition and obtained in Puget Sound near Seattle.

Cyclopterichthys has the skin perfectly smooth and the dorsal short, as in the other Cyclopterids. The only species (*C. ventricosus*) is an inhabitant of Bering Sea.[1]

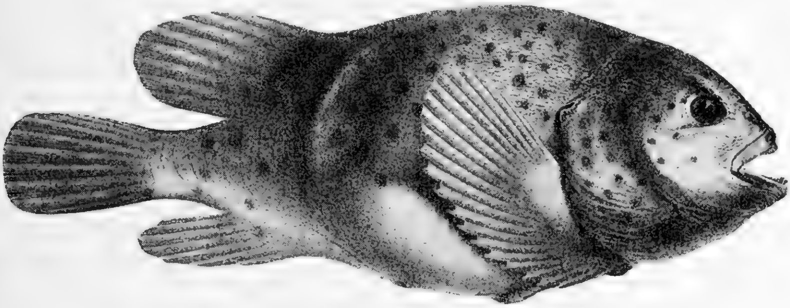


FIG. 42.—*Cyclopterichthys ventricosus*. After Steindachner.

Liparops has the skin in front of the dorsal surmounted by a row of bony tubercles and the dorsal comparatively long. A single species (*L. stelleri*) is known from Kamchatka.

III

The genus *Cyclopterus* has as the chief distinctive characters a massive body, very high arched back, skin covered with large tubercles in seven rows, a median dorsal and three lateral on each side, and much smaller scattered tubercles over the rest of body and head, small head, moderate branchial apertures (large in comparison with other genera of the family, extending from a level above the eyes to the front of the pectorals), the soft dorsal and anal pushed far back and opposite, and the spinous atrophied and concealed by the overgrown tubercles in adults. The type and only known species is the strange-looking and celebrated Lumpsucker.

The name *Cyclopterus* (meaning circular fin) was given by Linnæus in allusion to the circular form of the combined ventral fins.

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[1] A second nominal species has been added to *Cyclopterichthys* and named *C. amissus*. It is based on a sketch of a fish caught at Telly Bay, Magellan Strait, made by a naval officer, and was the only material Professor Vaillant had to determine the species. It has, however, been admitted by Mr. Garman (The Discoboli, 1892, p. 42), who has cited "Gill, 1891, Pr. U. S. Nat. Mus., XIII, 366," as also adopting it. The present writer, however, especially stated "the so-called *Cyclopterichthys amissus* has no real standing in the ichthyological system."

The popular names are many and several somewhat significant. Besides Lumpfish and Lump alone, Lumpsucker is given, and recalls both the "lumpy form" of the body and the suctorial character of the ventral fins. Paddlecock or Paidlecock, as well as Cock-paidle, Scotch names, are reminders of the crest of the back, which has some resemblance to a cock's comb, as well as the toad, whose skin its own is not unlike; the sexual differences, so apparent when mature, have obtained contrasting names, for the female is distinguished as the Hen-paidle, and the sexes are frequently spoken of as cock or hen, or, on account of the differences of color, Red-paidle and Blue-paidle. Other names less used are Sea-owl and Hush-bagaty. Lumpfish is the generally accepted name of the Americans.

Lumpfish is evidently cognate with Lumpfisk of the Baltic shore, Lump of the German and Netherlanders, and Lomp of the French. Paidle and Paddle have been ascribed to the verb to paddle, but are much more likely cognate with the Dutch and Danish Padde, the name of the toad. One of the Danish names of the Lumpfish, indeed, is Hafpadde or Sea-toad.

IV

The Lumpsucker's distribution in the North Atlantic is wide both in a horizontal and vertical direction. As a lover of cold waters, however, its range southward does not extend below the Bay of Biscay along the coast of Europe, nor beyond Chesapeake Bay along the American coast, and there rarely.[1] Its range northward (as elsewhere) is probably limited by the conditions of its oviposition and development, so that it does not thrive in the high Arctic Ocean. Its chief resorts are along the Scandinavian coasts and those of Scotland as well as Greenland, and along the northern American shores to Cape Cod. Within such limits, in almost all suitable places, it is one of the most common of fishes.

It is a "bottom-fish," generally keeping close to or on the bottom, but its range is great, extending from tide-limits to a depth of between 100 and 200 fathoms. The bottom mostly affected is a rocky or stony one and, by means of its sucker, it often adheres to such

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[1] A female lumpfish over 18 inches long was recently obtained by fishermen near the entrance to Chesapeake Bay, and carried to Washington as an unknown and curious specimen. Word was sent to the Smithsonian Institution, and Mr. Barton A. Bean went to the wharf and obtained it. None of the observers had ever seen or heard of the like. The specimen is now in the collection of the U. S. National Museum.

and remains inactive for a long time—many minutes. However, it is by no means restricted to such, but, according to Smitt, "may sometimes be found swimming freely about in the open sea. This does not depend entirely on the circumstance that it attaches itself to floating objects and drifts about in their company, for it also displays considerable activity in the pursuit of its prey and in its migrations to the spawning place."

It nevertheless frequently avails itself of foreign objects. "Ekström mentions its habit of attaching itself to the wooden floats or buoys used to support the herringnets" in Sweden, but individuals may even make use of living fishes. An instance was published by Couch of one that had secured a hold on a mackerel, the two having been caught together in a drift net in water of considerable depth. Probably in this instance the attachment resulted from fright. The tenacity with which a Lumpsucker can adhere to another body is remarkable. Pennant long ago told that, when put "into a pail of water," by its sucker it fixed itself "so firmly to the bottom that on taking it by the tail the whole pail by that means was lifted, though it held some gallons." McIntosh found this observation to be quite accurate. "The whole can be lifted by seizing the fish, and a greater weight than 43 pounds (which was that of pail and water) could readily be raised in this manner."

The Lumpsucker's movements in progression are characteristic. Buckland (1880) considered that, "though an awkwardly built fish, it is a good swimmer. The tail is the propelling power, and the fish moves it with great velocity and an action not unlike a clumsy woman running." Such a course, however, could only be maintained for a short time, and while good for a rush, would not suffice for a long tour. The rushes are most observable during the season of incubation, when the male assumes charge of a bunch of eggs. Then the usual lethargic and peaceful fish becomes an active as well as vigilant guardian of the future progeny. He rushes at an intruder, especially an intruding male of his own kind, "with the utmost fury" and wonderful agility. One, like Fulton, could scarcely believe "that so clumsy and usually sluggish a fish could swim so fast."

The feeding habits of the Lumpsucker are peculiar. The fishermen of some places, especially along the coast of Belgium, according to Van Beneden (1876), maintain that "the *Cyclopterus lumpus* feeds on nothing but the excreta of other fishes," and Van Beneden even endorsed this belief to the extent of affirming that "the examination of the animal's stomach confirms their assertion," and consequently he ranked the fish among "crotophagous species." Later (1902)

Fulton recorded the results of the examination of "considerably over three hundred specimens of Lumpsuckers." "The stomachs of a large proportion of them were either empty or filled with a watery fluid of about the same specific gravity as ordinary sea water." One hundred and forty-four of the fishes thus examined were caught "in the nets of the salmon fishers," and had approached the shore to spawn. The concentration for this purpose may partly at least account for the emptiness of the stomachs. "The great majority of the stomachs of female fishes examined" by Fulton "were either empty or contained a thin fluid differing little, if at all, from sea water. The stomachs containing food which could be most easily identified were usually those of male fishes." The food was chiefly composed of small crustaceans, especially isopods or amphipods, and cœlenterates, such as Beroids and Pleurobrachia.[1]

In fact, crustaceans, medusans, worms,[2] and shell-less mollusks are the main sources of supply, but the medusans were thought by Lilljeborg (1884) to have been ingested rather for the small hyperioid crustaceans that lurk about them than for the jelly-fishes themselves. Some incautious little fishes are also captured by it. Murie, indeed, found on one occasion about a hundred "whitebait" (the young of herrings and sprats) in the stomach of a single Lumpsucker. Other observers have examined the stomachs of many individuals, especially females in the breeding season, without finding anything "save a quantity of fluid," but, as Fulton has well remarked, "this is no doubt owing to their being mostly caught during the breeding season, when food is usually not taken by fishes." An incident told of by Fulton (1906) aptly illustrates the limitation of the fish's power and its abstinence while guarding the eggs whose care it has assumed. One day Fulton "dropped on the top of the egg-mass" a male was guarding "a little common swimming crab, about 1¼ inches in breadth, which, apprehending danger, clung tightly in one of the snout-depressions on the surface of the eggs. It was amusing to watch the Lumpsucker ineffectually trying to rout him from the hollow in which he had taken refuge, the blunt snout of the fish preventing a hold being got on the crab. He tried again and again to dislodge or seize the crab. At last the crab turned partly on its side and extended its widely opened chelæ as if to defend itself, which

[1] A detailed account of Fulton's observations may be found in the 20th Annual Report of the Fishery Board for Scotland, part 3, pp. 497-500.

[2] Prof. McIntosh (3d An. Rep. F. B. Scot., p. 61) obtained "a large female" which emitted "fully matured" ova whose "stomach was distended with fine specimens of *Nereis pelagica, L.*"

gave the fish its opportunity. It seized the crab in its mouth and swam off with it to the furthest corner of the tank, where it dropped it." Under other conditions, doubtless, it might have at once swallowed it.

V

The spawning season is quite long, extending from February to June, the season depending somewhat on the temperature and place, but even in a single place it may be prolonged. McIntosh, for instance, found that at St. Andrews "it ranges from February to May," and he was corroborated by Fulton (1906), who found that the spawning season for Scotland generally extended "from February to nearly the end of May." In one year noted by McIntosh (1886) "it was especially late, probably from the severe and long-continued winter. The young captured during the first ten days of July therefore showed considerable variation in size." Fabricius records that in Greenland oviposition occurs about the end of May or the beginning of June, the abbreviation of the season doubtless being determined by the brevity of the summer.

The male parent has been long known to keep a watchful guard of the eggs of the female, and it has been even claimed that he made a nest. McIntosh, however, especially asserts (1886) that "the *Cyclopteri* form no *nests,* the ova being deposited chiefly on the sides of rocks and stones." Often the precious burden is laid in such low water as to be almost exposed at low tide, and the zealous male, regardless of danger, is then so careless of self as to permit a close examination. McIntosh (1886) has given interesting details respecting one he had observed:

"About the middle of May a male *Cyclopterus* was found a short distance from low-water mark in a broad runlet with his head close to a mass of ova placed in the seaward edge of a stone. The stream of sea-water was so shallow as to leave the stone partly exposed, and was quite insufficient to float the fish, which was 11½ inches in length. Accordingly, for a considerable period twice daily the devoted male had to lie in the runlet on his side, a portion of his body, including the upper opercular region (in this position), being above water. From the situation of the ova on the stone just described the current of the runlet flowed into the mouth of the fish, which, in the warm sun of June, must have been less comfortable than under ordinary circumstances—a fact which is at variance with the 'accidental' theory formerly mentioned. The cool and ever-changing stream, however, sufficed for aëration, the movements of the hyoidean apparatus and the mandible, as well as the direction of the stream, causing a current over the upper as well as the lower branchiæ. Thus, although the action of the branchial apparatus and the heart was occasionally a little hurried in the warm sun, no serious effect ensued. For five or six weeks this faithful male was found at low water in this position, sometimes on one side and sometimes on the other. In order to test it still further, Mr. Scharff removed the fish a couple of yards from the eggs and placed it on a stone. It wriggled actively into the water, at once rushed to the ova, and assumed its former position with the snout almost touching the eggs. The same ensued when it was placed in the runlet at a somewhat greater distance. The solicitude of the males for the ova which they have under charge was further illustrated by the occurrence early in May of a heavy sea, which swept masses of the ova from their positions all along the rocks. As soon as the sea became calm numerous anxious males, like 'pilgrims,' were seen by the laboratory attendant (who had been familiar with the sites) seeking for their lost charges. Many of these masses of eggs were found on the beach, so that the statement is probable.

"As soon as the eggs were hatched the male was released, and the young spread themselves over the rock-pools in the neighborhood in hundreds. It is unlikely, however, that they are dispersed by specially adhering to the body of the male, though they quickly cling to anything and even to each other. Their home appears for some time to be the littoral region and especially the rock-pools, and they are occasionally found in considerable numbers in August, when the larger examples caught with a hand-net measured about 7/8 inch. They adhere to the blades of the tangles and other seaweeds, and in the mazes of these find that safety (from the ready application of their suckers) which would be denied them in the open sea. When caught in the tow-net inshore it is generally along with floating littoral seaweeds with which they have migrated."

Fabricius (1780), generally a reliable authority, has told an extravagant story of the valor and ability of the paternal Lumpfish. According to him it fears no enemy; even if the Wolf-fish, armed though it be with terrible teeth, approaches its nest, it is wont to pursue it and, fastening on its neck, bite and worry it to death. One who knows the comparative structure of the two fishes must find it difficult to credit such a tale. Nevertheless Fulton (1906) does "not think the story of Fabricius . . . need be doubted. The courage and pugnacity of this usually docile and inoffensive fish seem boundless when it is protecting its eggs, and in contests of this kind it not infrequently happens that courage and determination count for as much as strength and the power of inflicting real injury." In this case it is the ability and not the courage of the fish that need be doubted. The Wolf-fish that could be bitten and worried to death by a Lumpsucker must be small and weak indeed. McIntosh asserts that "even in its larval condition the young [Wolf-fish] makes an easy prey of the young [Lumpsucker]." The Lumpsucker's ability as a fighter is, in fact, very limited. His frame and jaws are weak; his teeth small and insignificant as weapons. As Fulton remarks, "his capacity as a defender of the eggs lay more in his power of butting than of biting, for which his mouth is not well adapted."

The female naturally becomes proportionately turgid with the growth of her eggs, and is "dark leaden blue or slaty colored"; the male assumes a bright reddish hue about his fins and his belly.

There is a considerable disparity in size between the sexes, the females averaging considerably more than a foot in length, while the males are less. Seventy "lumpsuckers taken from a salmon stake-net in the Bay of Nigg," Scotland, "between 2d May and 24th July" of one year, were measured by Dr. Fulton; of these 40 females averaged nearly 16 (15.8) inches in length and 6 pounds and 6 ounces in weight, while 30 males averaged 11 inches long and only a pound and 14 ounces in weight.

The eggs themselves are noteworthy for their gay and diverse colors. According to Fulton, "when examined in the ripe female before extrusion they are usually reddish or salmon tinted, but may be lilac, pale violet, pale brown or pink. On extrusion they are pink, but this tint fades on exposure to light, and gives way to a faint greenish or yellowish hue; later they become dark, owing to the development in the embryos." In mass, they may constitute a quarter to a third or more of the total weight of the mother. "The average for three specimens examined" by Fulton was "27 per cent." The same observer found that "the eggs measure about 2.2 mm.–2.6 mm., and have a volume of 4.18 cc." He estimated "them to number from 79,758 to 136,764 in females a little over 18 inches long. The fecundity of the Lumpsucker is therefore high."

The favorite time for sexual congress appears to be night. Doubtless then males and females chiefly meet, but their manner of approach and love play, if any, have not been reported. Probably there is a mutual excitation and play of the sexes. Then the female deposits a mass of eggs on some suitable ground and they are duly fecundated by a male fish. Perhaps there may be male rivals in waiting for this function, and a fight then ensues. The deposit of eggs is made on the bare rock or stones or the ground, generally "about low-water mark."

As a rule, the female lays all her eggs "at one time," but occasionally they are deposited in two or perhaps more lots. "One of the females" observed by Fulton "deposited her eggs in two lots after an interval of thirteen days. The eggs in the ovary, just before extrusion, are bathed in a plentiful fluid, but they are not adherent; when the fingers are passed through the mass, the feeling conveyed resembles that of contact with a mass of half-boiled sago. Around the eggs the secretion is syrupy, and on separating them glutinous threads pass between them. This substance hardens in sea water and binds the eggs into a large, compact, spongy mass, leaving narrow channels between them by which water enters."

Some excellent observations were made in 1906 by Dr. T. Wemyss Fulton, in Scotland. A couple of males were confined in an aquarium with two females, both of which "laid their eggs in the same corner." On the 24th of March one victorious male assumed charge of both deposits and "showed throughout the whole period" of development of the eggs "the most rancorous and persistent animosity to the unattached one. The latter, on the other hand, displayed the greatest fear of his successful rival." The male "which was worsted in the nuptial fight never regained courage to attempt further contest for his rights, but displayed a most craven spirit from first to last, lurking in the darkest part of the tank as far from his rival as he could get. * * * Whenever the guarding male saw his late opponent moving, even a comparatively little way from his retreat, he rushed at him with the utmost fury. * * * and the other male made off with equal speed and often attempted to jump out of the water, or was partly knocked out. On such occasions so much commotion was made that waves were created in the tank and the other fishes were alarmed. These were the only occasions that the guardian left the eggs for a few moments. The animosity was kept up during the whole period of the experiment, * * *. The females took no part at all in looking after the eggs. * * * They lay indolent and quiet at the back of the tank for some days." The victor male enjoys exemption from the further intrusion of a beaten rival.

The guardian male, while constant in his attention to his charge, varies in his position; sometimes he rests by the side of the mass and sometimes he may turn his back on the eggs and cling to a corner or wall next to which they have been laid. The Lumpfish in the aquarium which Fulton observed would mostly "lie behind them, with his snout against them, and obviously keenly attentive to his surroundings as well as to the responsible duties of his office." Not infrequently, however, he would attach himself by his sucker to the wall of the tank next to the eggs, with head upward. A sea-anemone close to the eggs was never interfered with.

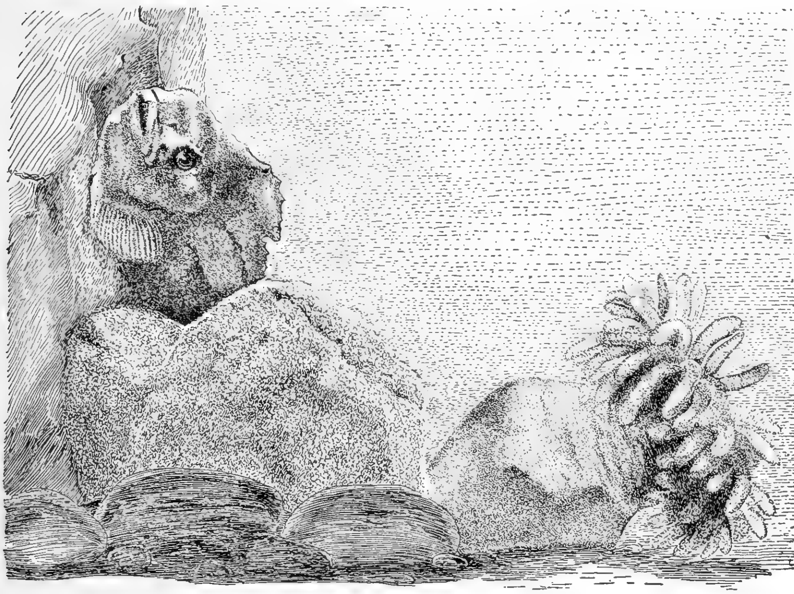

FIG. 43.—Male Lumpfish guarding egg masses. (Sea-anemone at right undisturbed.) Modified after Williamson and Fulton.

But something more than vigilance against intruders is required of the parent fish. The charge assumed by him demands still more active duties. In the case of the fish observed by Fulton, after a time "the guarding male was observed to fan gently the mass of eggs with his breast fins, clearly for the aëration of the eggs, but for some time the action was leisurely performed and was by no means so striking as it became later." Some ten days after the assumption of his charge the male resorted to a still more efficient means of aëration. "Placing his mouth about an inch or so from the spawn, he spouted water out upon it, the action of the gill-apparatus being thus reversed. * * * This curious action was most purposive and effective. The current created was so strong as to sway the algæ growing on the side of the tank in the neighborhood as well as the tentacles" of a sea-anemone close by the eggs, "and even to cause the whole mass of eggs to rock visibly backwards and forwards. This action was done at brief intervals and from this time onwards. Later, when the eggs were hatching, it was redoubled, and great activity was shown with the fins. The movement thus created in the water very probably helped the escape of the larval fishes from the eggs. At this time the 'pumping' or 'blowing' action was at the rate of fifteen or sixteen in ten seconds, and in the pauses the fins were kept vigorously at work."

For more than a month this guardianship of the eggs was kept up and for most of the time no food whatever was taken. If any was dropped near him or on the eggs, such as mussels, he would remove them; a little crab dropped on the eggs was, after some effort, caught and carried away to be dropped instead of eaten, as already told. This vigilance and restraint at length changed his appearance. He "lost his brightness" and became dingy; naturally he also became thin and was infected with ecto-parasites (*Caligi*) and appeared sometimes exhausted by his onerous task and prolonged fast. But "that this was not entirely due to those causes was shown when the supply of water was increased, and when it was directed to his corner. After a refreshment of this kind he moved about with vigor, energetically spouting water on the eggs and fanning them with his fins." Not until the 26th of April was the watchful male persuaded to take a mussel, but after that "on some days he ate as many as five; any excess he carried off and ejected, as before; and at the beginning of May he was as alert, active, and pugnacious as ever." Once persuaded, he occasionally accepted food several times afterwards.

At last, on the 5th of May, "42 days after the eggs were deposited and fertilized," larvæ began to issue from the eggs; for the first few days "the tadpole-like larval lumpsuckers were found in small numbers in the overflow-filter every morning, and they slowly increased in numbers. They were very active, swimming with great rapidity by a lashing movement of the tail, a large yolk containing an oil globule at the right side being conspicuous. Up to the 22d of May, or almost exactly two months from the time the eggs had been spawned, and seventeen days after they had begun to hatch, the conditions described continued. The young lumpsuckers were appearing in greater numbers, but still not in such abundance as one might have expected. The largest number was about two or three hundred a day. They were also to be seen adhering to the glass front of the tank, and numbers were thus accounted for. None were observed on the back of the male, a habit sometimes attributed to them."

No more eggs were hatched after the 22d of May. "The greater number were still unhatched on that day," but the remainder of the mass of eggs were "black and fetid" and many of the larvæ were "dead and white" and "floating on the water." "Clearly the aëration had not been sufficient for the interior of the egg-masses." Fulton believed that, under natural conditions, "the time taken for the hatching of all the eggs is prolonged, for it is difficult to understand how the larvæ could make their way from the interior of the mass by the narrow channels between the eggs if the eggs there were hatched as soon as those in the exterior."

Doubtless, under natural conditions, protected by the vigilance of the father fish, a large majority of the eggs are hatched and the larvæ escape to live a free life for more or less time. Doubtless, too, a greater loss of life is then incurred than during their hatching period, for they no longer enjoy their father's care. Their early developmental history has been detailed by A. Agassiz (1887), W. C. McIntosh, and A. T. Masterman (1897).

As soon as the eggs are hatched the male is released and the young disperse all around, resorting to the rock-pools in the neighborhood in hundreds. The rock-pools and the littoral region in general are the chief resorts "for some time." There they were found by McIntosh and Masterman, in Scotland, to later adhere to the blades of the tangles and other sea-weeds, and in the mazes of these they would "find that safety (by the ready application of their suckers) which would be denied in the open sea. They are also common in the neighboring waters inshore, being carried hither and thither on the floating littoral sea-weeds."[1] (See also p. 140.)

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[1] The young are protected to a considerable extent by assimilation to surrounding objects. According to W. A. Smith (11th Rep. F. B. Scotl., p. 390), "perhaps the simplest and most interesting example of such assimilation is to be found in the young of the Lumpsucker." Smith observed "the young in multitudes, when the capsules were being thrown from the" olive-green seaweed amongst which they lived, hovering about "and making no effort to escape, further than dodging alongside one of the capsules which was an exact counterpart of itself, both in size and general tone of coloring." H. C. Williamson (17th Rep., p. 128) also called attention to the fact that young Lumpsuckers "were found at the surface on drifting pieces of Fucus." Smith, probably mistakenly, thought that these young, "only one inch in length," were "probably a year old or thereabouts," and that fishes weighing "12 or 14 pounds must be of great age." Tosh estimated the age of an inch-long (22 or 23 mm.) fish to be five months.

VI

The newly hatched larvæ are about a sixth to a quarter of an inch (4-6 mm.) long or a little more. "They are tadpole-like—with the remains of yolk, the oil-globule, occupying the right side, while the marginal fin is continuous, dorsally and ventrally. The caudal has only embryonic rays, and there is a thickening (hypural) beneath the notochord in this region. The short breast-fins show indications of true rays. The circulation in the vessels of the yolk-sac goes on in jerks, so different from the continuous rapid currents in the arteries of the tail and other parts. The dorsal aorta bends downward just within the tip of the notochord. The young Lumpsuckers swim very actively by rapid vibrations of the tail and the pectorals. The heavy anterior end of the body is thus favorable for progression." Such were the larvæ obtained by McIntosh and Masterman in early May. "By the 12th day the fish has increased considerably in bulk, and measures 6.75 mm."; the yolk has disappeared, the fins become differentiated, the two dorsals especially showing distinct rays; the anal, however, though rayed, is "joined to the caudal by a strip of larval fin without rays;" and the caudal is still heterocercal.

FIG. 44.—Young Lumpfish 4 mm. in length. After A. Agassiz.

From this earliest stage with the continuous fin round the long postanal region there is a regular development into the adult stage.

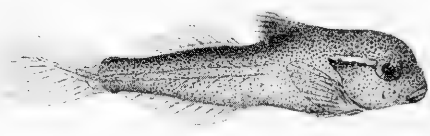

FIG. 45.—Young Lumpfish 10 mm. long. After A. Agassiz.

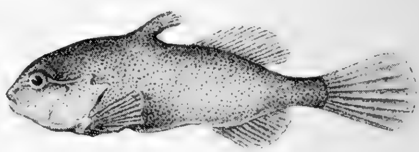

FIG. 46.—Young Lumpfish 20 mm. long. After A. Agassiz.

The tail end becomes abbreviated and concentrated; a division ensues between the caudal, dorsal, and anal fins; the heterocercy diminishes and is at length replaced by the homocercal tail; the first dorsal, originating in a protuberance which becomes quite upraised, finally becomes distinctly developed, and lastly the dermal appendages are developed, the lateral tubercles extending from the shoulders first, then the larger tubercles behind from the pectoral region. The concentrated oviform shape is the last phase assumed.

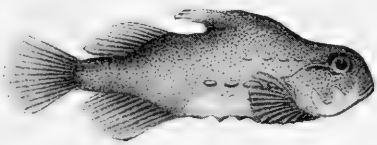

FIG. 47.—Young Lumpfish 34 mm. long, showing rows of tubercles. After A. Agassiz.

The essential cyclopterus form thus acquired, further development is chiefly in the line of increase in size and bulk. The growth is rather slow. When a year old, the young fish is about two inches or more in length.[1]

Maturity is probably attained during the third or fourth year. According to Fulton (1892) the "average length" of a mature female is about 18 inches and that of a male between 10 and 11 (10.8) inches.[2] An average-sized female would weigh about 10 pounds.[3]

VII

A considerable diversity of opinion prevails respecting the gustatory quality of the Lumpsucker. In many places (as in the United States, Canada, and even in France) it is seldom or scarcely ever eaten. One of the objections against it is on account of its smell, or because, as Moreau and Day euphemistically state, "it diffuses an odor which is by no means pleasant." Moreover, "the quality of its flesh is said to be affected by the season, it becoming worthless after spawning," according to Day. It is also said "to dissolve in the mouth like mucilage or oil." In England, formerly it was more

[1] According to J. R. Tosh (12th Rep. F. B. Scotl., 1893, pt. 3, p. 333), a fish caught June 1, 1887, 53 mm. long, had a "calculated age" of a year, the probable month of spawning" having been May. (See also p. 145.)

[2] Fulton's deductions (10th Rep. F. B. Scotl., p. 239) were based on 30 individuals and a ratio of 6 females to 24 males.

[3] According to Fulton (9th Rep., p. 253), one female 18⅝ inches long, weighed 10 pounds 10 ounces; another, 18½ inches long, 10 pounds 9½ ounces, and a third, 17⅛ inches long, 7½ pounds. The eggs varied from 79,758 to 136,764; the smallest number was yielded by an 18½-pound fish. The mean ratio of weight of mature ovaries to that of fish is more than a quarter (266.51) and varies at least between 223 and 348 (9th Rep., p. 245).

used than now. Sir Thomas Brown (1662) declared it to be "esteemed by some as a festival fish, though it affords but a glutinous jelly, and the skin is beset with stony knobs after no certain order." Buckland thought that the males are best as food, their flesh being soft, rich, and oily—doubtful recommendations for Anglo-American tastes. In Scotland and northern England the fish appears to be held in higher esteem than elsewhere; "some inhabitants of Edinburgh deem it second only to the Turbot if fried or baked," and in Berwickshire "the cock especially is reported to be excellent when fried or baked." Scotch appreciation of the value of the fish is betokened in "The Antiquary" of Walter Scott. The knowing hero, Jonathan Oldbuck, puts the Turbot or Bannock-fluke and male Lumpsucker on a par. "I'll bid you fair, I'll bid you a shilling for the Fluke and the Cock-padle, or six-pence separately," and closes with the fishwife by giving half-a-crown for the two "and a half-a-dozen o' Partans [crabs] to make the sauce" (chap. 11). The sister housekeeper, while objecting to the price, does not object to the comparative valuation (chap. 14).

On the other hand, along the west coast of Scotland, "the fishermen boil them down with vegetables for their pigs"; for that purpose at least they "consider them to be fattening food."

Fabricius long ago (1780) told that the Greenlanders eat the flesh cooked or dried, as well as the skin from which the tubercles only have been taken; the ovaries are also used, cooked with the liver or dried, while the eggs themselves are eaten raw.

Tosh has recorded (1894) that along the eastern coast of Scotland "the fishes are very abundant," and "when they come close inshore to spawn they are a great nuisance to the salmon fishermen."

Olden belief and superstition assigned to the Lumpfish a curative value, doubtless on the principle that, being ugly and uncanny, it must have sanative qualities. According to Ekstrom and Smitt, in the Danish Mörkö, "the few specimens that are caught are never used as food. They are employed only as a remedy for ague. For this purpose the fish is thoroughly dried in an oven and pounded to a powder. The powder is then taken in corn-brandy, in doses of a spoonful." Verily, the sick have been made to suffer among the ignorant!

NEW PLANTS OF THE PACIFIC SLOPE, WITH SOME REVISIONS

By CHARLES V. PIPER

The following botanical notes, accumulated by the writer while studying the plants of the State of Washington, relate particularly to the neighboring States. Several new species are described, and there is also included a critical study of the subspecies of *Cassiope mertensiana* and a revision of the species of *Orthocarpus* related to *O. imbricatus*. The types of all the new species are deposited in the United States National Museum.

CASSIOPE MERTENSIANA AND ITS SUBSPECIES

CASSIOPE MERTENSIANA (Bong.) G. Don.

Cassiope mertensiana (Bong.) G. Don, Hist. Dichl. Pl., 3:829. 1834.
Andromeda mertensiana Bong., Mem. Acad. St. Petersburg, VI, 2:152. 1832.
Andromeda cupressina Hook., Fl. Bor. Am., 2:38. 1834.

Type from "Rocky Mountains north of the Smoking River, latitude 46°.—*Drummond*." This locality is, however, really about latitude 56.° The type specimen of *Andromeda mertensiana* is from near Sitka, Alaska.

This beautiful plant, in its typical form, ranges from Alaska south in the Rocky Mountains to about the 49th parallel, and in the Cascade Mountains to the Three Sisters, Oregon. The species is characterized by having, among other traits, minutely puberulent stems and peduncles, leaves not at all ciliate, and entire calyx lobes. Southward from the above-mentioned points, none of the plants heretofore referred to *C. mertensiana* are in agreement with these characters, and this material represents, we believe, three well-marked subspecies.

CASSIOPE MERTENSIANA GRACILIS Piper, subsp. nov.

Stems and peduncles glabrous; leaves 2 to 3 mm. long, smaller and more densely crowded and less distinctly 4-ranked than in typical *C. mertensiana;* flowers 4 to 5 mm. long, smaller than in *C. mertensiana* and on much longer peduncles, 10 to 20 cm. long.

The following specimens have been examined:

OREGON:

Wallowa Mountains, *Piper*, 2,472, August, 1896;
Cusick, 235; also 1,723 in 1897.

IDAHO:

Near Sawtooth, *Evermann*, 657, July 26, 1896;
Salmon River Mountains, altitude 3,180 meters, *Henderson*, 3,909, August 20, 1895.

MONTANA:

Belt Mountains, *Scribner*, July, 1883;
Old Hollowtop, altitude 2,400 meters, *Rydberg & Bessey*, 4,659, July 7, 1897;
Spanish Peaks, altitude 2,700 meters, *J. Vogel*, July 20, 1897.

This subspecies was mistaken by Doctor Gray[1] for *C. lycopodioides* (Pall.) D. Don, an Alaskan species easily distinguished by its scarious-margined smaller leaves. It is owing to its small leaves and long-peduncled flowers that our plant has a superficial resemblance to *C. lycopodioides*.

Type specimen.—Sheet no. 529,987, U. S. National Museum (Piper's no. 2472).

CASSIOPE MERTENSIANA CILIOLATA Piper, subsp. nov.

Stems and peduncles glabrous; leaves cilolate with delicate white fugacious hairs; calyx lobes entire; otherwise as in *C. mertensiana*.

Apparently confined to Siskiyou County, California, whence the following specimens have been examined:

Cliffs, Castle Lake, *Pringle*, August 5, 1882;
North of Mount Shasta, *H. E. Brown*, July, 1897;
Mount Eddy, altitude 2,550 meters, *Copeland*, 3,898, August 18, 1903.

Type specimen.—Sheet no. 444,503, U. S. National Museum (Copeland's no. 3898).

CASSIOPE MERTENSIANA CALIFORNICA Piper, subsp. nov.

Stems and peduncles glabrous; leaves rather large; 3 to 5 mm. long, very minutely glandular-ciliate; calyx lobes and corolla lobes more or less erose-denticulate.

In the Sierra Nevada from Lassens Peak southward. The following specimens have been examined:

CALIFORNIA:

Mount Lyall, altitude 3,300 meters, *Hall & Babcock*, 3,578, July, 1902;
Ridge above Donner Pass, altitude 2,250 meters, *Heller*, 7,131, August 10, 1903;
Carson Spur, Amador County, altitude 2,550 meters, *Hansen*, 795, July, 1893;

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[1] Syn. Fl., 2^1: 36. 1878.

Mount Stanford, *Sonne,* 205, July 25, 1887;
Above Coldstream, Placer County, altitude 2,400 meters, *Sonne,* July 31, 1892;
Mount Dana, *Bolander,* 6,019 in 1866;
Lassen's Peak, *Lemmon* in 1875;
High Sierras, *Brewer,* 2,805 in 1864, 1,791, 2,124.

Type specimen.—Sheet no. 443,928, U. S. National Museum (Hall and Babcock's no. 3578).

ORTHOCARPUS TENUIFOLIUS AND ITS RELATIVES

Orthocarpus tenuifolius (Pursh) Benth. and its near allies compose a group of species in which the bracts are strikingly and abruptly different from the narrow leaves, being broad and more or less colored, while they become papery and closely imbricated in the fruiting spike.

In the Synoptical Flora Doctor Gray recognized but two species, which he increased to three in a revised treatment in the supplement to the same work. Since then four other closely related species have been described, namely, *O. cuspidatus* Greene, *O. barbatus* Cotton, *O. olympicus* Elmer, and *O. copelandii* Eastwood. *O. olympicus* seems indistinguishable from *O. imbricatus* Torr., and *O. copelandii* is the same as *O. cuspidatus.*

A recent examination of the material in the National Herbarium is the basis for the treatment here proposed, in which one new species is described, making six recognized in the group. They may be distinguished by the following synopsis:

Key to Species

Galea uncinate at the tip; bracts obtuse or some of the lower ones acutish, all more or less purple-tinged.
- Corolla 25 to 30 mm. long; galea much exceeding the lip; fruiting calyx firm, not scarious, the subulate-lanceolate teeth as long as the tube; anther cells linear, curved .... *O. pachystachyus.*
- Corolla 12 to 15 mm. long; galea little longer than the lip; anther cells oval.
  - Fruiting calyx not scarious, its narrow teeth as long as the tube; corolla yellow, minutely pubescent; capsule oblong, elliptic; herbage scabrous and sparsely hirsute-ciliate .... *O. tenuifolius.*
  - Fruiting calyx scarious, its triangular-subulate teeth much shorter than the tube; corolla purplish, glabrous or minutely pruinose; capsule oval; herbage merely puberulent .... *O. imbricatus.*

Galea straight, its tip glandular-pubescent; bracts all acute, yellow or greenish.
- Calyx teeth not scarious, conspicuously ciliate; corolla yellow, slender, the tip of the galea very pubescent .... *O. barbatus.*

Calyx teeth scarious-margined, little or not at all ciliate; corolla purple.
Corolla 15 to 18 mm. long, somewhat funnelform, the lower lip large and conspicuously inflated, much broader than the galea. *O. cuspidatus.*
Corolla 12 mm. long, tubular or nearly so, the small lip not broader than the galea.................................... *O. cryptanthus.*

ORTHOCARPUS PACHYSTACHYUS Gray

Orthocarpus pachystachyus A. GRAY, Syn. Fl., 2^1: 300. 1878.

This species was discovered near Yreka, Siskiyou County, California, by Dr. E. L. Greene, and seemingly has not since been collected.

ORTHOCARPUS TENUIFOLIUS (Pursh) Benth.

Orthocarpus tenuifolius (PURSH) BENTH., Scroph. Ind., 12. 1835.
Bartsia tenuifolia PURSH, Fl. 2:429. 1814.

The type of this was collected by Lewis "on the banks of Clark's River," the exact locality on the Bitter Root River at the mouth of Lou Lou Fork, Montana. A duplicate type is in the Philadelphia Academy of Sciences. Specimens have been examined as follows:

WASHINGTON:
Wilbur, *Henderson,* July 12, 1892;
Spokane County, *Suksdorf,* June 28, 1884;
Clarks Springs, *Kreager,* 18, June 24, 1902;
Pullman, *Piper,* 1,666, July 20, 1903; *Elmer,* 168, July 2, 1896;
Okanogan to Grand Coulée, *Wilkes Expedition.*

IDAHO:
Lake Waha, *Heller,* 3,379, July 4, 1896;
Moscow Mountain, *Sandberg, Heller, and MacDougal,* 458, June 20, 1892;
Hatwai Creek, *Henderson,* June 17, 1894.

MONTANA:
Battle Ground, mouth of Trail Creek, *Watson,* 322, July 24, 1880;
Bozeman, *Rydberg,* 2,787, July 22, 1895.

OREGON:
Without locality, *Kellogg & Harford,* 703;
Wallowa County, *Sheldon,* 8,265, 8,266, 8,404;
"E. Oregon," *Cusick,* 1,702, July, 1897.

ORTHOCARPUS IMBRICATUS Torr.; S. Wats.

Orthocarpus olympicus TORR.; S. WATS., Bot. King Surv., 458. 1871.
Orthocarpus olympicus ELMER, Bot. Gaz., 36:60. 1903.

Type of *O. imbricatus* "collected by Dr. Newberry on Williamson's Expedition in the Cascade Mountains, Oregon." The specimen in the National Herbarium is, however, labeled "Hat Creek, California, July 30."

Type of *O. olympicus* collected "in the Olympic Mountains, Clallam County, Washington, at an elevation of 1,000 to 1,500 m." Duplicate in the National Herbarium.

This species seems quite rare, and in addition to the above only the following specimens have been seen:

CALIFORNIA:

Mount Shasta and vicinity, *Palmer*, 2,435, July, 1892.

OREGON:

Hunt's Ranch, *Gorman*, 416, August 13, 1896;
Buck Lake, Klamath County, *Coville & Applegate*, 2, July 24, 1897.

WASHINGTON:

Olympic Mountains, *Flett*, August 27, 1898.

ORTHOCARPUS BARBATUS Cotton

Orthocarpus barbatus COTTON, Bull. Torr. Club, 29: 574. 1902.

Type collected at the "junction of Crab and Wilson Creeks, Douglas County," Washington, by Sandberg & Leiberg, no. 234, altitude 680 meters, June 19, 1893. It was also collected long ago by the Wilkes Expedition at Fort Okanogan, Washington, no. 1010, and listed by Torrey in the Botany of that expedition as *O. bracteosus* Benth. The species has since been collected in abundance by Griffiths and Cotton at Moses Lake, Douglas County, Washington.

ORTHOCARPUS CUSPIDATUS Greene

Orthocarpus cuspidatus GREENE, Pittonia, 4: 101. 1899.
Orthocarpus copelandii EASTWOOD, Bot. Gaz., 41: 288. 1906.

The type of *O. cuspidatus* was collected on Ashland Butte, near Ashland, Oregon, by Howell (no. 141), July 8, 1887. The type of *O. copelandii* was from Mount Eddy, Siskiyou County, California, altitude 2,130 meters. Various California specimens are to be referred here, namely:

Headwaters Sacramento River, at 2,100 meters altitude, *Pringle*, September 1, 1882;
Twin Lakes, Alpine County, at 2,600 meters altitude, *Hansen*, 455, July 22, 1892;
Mount Shasta, *H. E. Brown*, 499, 2,000 to 2,800 meters altitude;
Diamond Mountain, near Susanville, *Jones*, June 28, 1887, 2,230 meters altitude.

ORTHOCARPUS CRYPTANTHUS Piper, sp. nov.

Annual; stems erect, 10 to 25 cm. high, simple or with a few erect branches, puberulent, leafy to the spikes; leaves ascending, lanceolate, alternate, sessile, acute, 1 to 3 cm. long, puberulent, all entire or the uppermost with a pair of slender lateral lobes; bracts abruptly different from the leaves, firm and papery, closely imbricate, ovate, acute, about 1 cm. long, entire or the lowest with a pair of lobes near the base, glabrous or nearly so, the margins somewhat ciliate, purple-tipped, almost entirely concealing the flowers; calyx 7 to 9 mm. long, cleft anteriorly to the middle and posteriorly nearly to the base, each lobe cleft about half way into two triangular-subulate teeth, the sinuses of these somewhat scarious; corolla purple, 13 mm. long, tubular or very rarely funnelform; galea straight, blunt and slightly pubescent at tip; lip about as large as the galea and nearly as long, somewhat triply saccate, ending in three small appendages; capsule broadly elliptic, 6 to 7 mm. long.

A species closely allied to *O. cuspidatus* Greene, but distinguished by its smaller corolla with relatively much smaller lip.

Specimens have been examined as follows:

OREGON:

Stein Mountains, near Wild Horse Creek, *Cusick*, 2,035, July 14.

Stein Mountains, opposite Andrews, altitude 1,850 m., *Leiberg*, 2,531, July 9, 1896.

Warner Range, Lake County, *Coville*, 619, July 26, 1906.

CALIFORNIA:

Lower end of Donner Lake, *Heller*, 6,884, July 8, 1903.

Type specimen.—Sheet no. 354,760, U. S. National Museum (Cusick's no. 2,035).

NEW SPECIES OF THREE GENERA, WITH A NEW NAME

SAXIFRAGA ODONTOLOMA Piper, nom. nov.

Saxifraga odontophylla PIPER, Contr. Nat. Herb., 11:314. 1906, not Wall. 1834.

LUPINUS GORMANI Piper, sp. nov.

A silvery-pubescent perennial about 20 cm. high, the underground portion of the stems and the very large root woody; stems slender, sparsely appressed-pubescent; basal leaves none, the lower cauline represented by bracts; normal leaves 5 to 7-foliolate, the leaflets oblanceolate, obtuse, acute or short-acuminate, 2 to 2.5 cm. long, pubescent on both sides with rather scanty silvery hairs; petioles shorter than the leaflets; stipules small, subulate-lanceolate; raceme 8 to 12-flowered, 4 to 5 cm. long, on a peduncle less than half its length; bracts lanceolate or subulate, early deciduous, shorter than the buds; pedicels 3 to 4 mm. long; calyx pubescent, bilabiate, the upper lip bidentate, 5 mm. long, the lower entire, somewhat longer; corolla apparently pale violet, 10 mm. long; banner orbicular, smooth on the back; wings obliquely oblong-obovate, smooth within; keel strongly falcate, slightly exceeding the wings, not ciliate; ovary hairy, 6-ovuled; pods not seen.

Type material collected on the middle peak of the Three Sisters, Oregon, at 1,920 meters altitude, by Mr. M. W. Gorman.

Type specimen.—Sheet no. 529,988, U. S. National Museum.

The species is nearest related to *L. albicaulis* Dougl.

CASTILLEJA ELATA Piper, sp. nov.

Perennial, from slender, creeping rootstocks; stems erect, rather slender, simple or with a few slender branches, 50 to 90 cm. high, glabrous; leaves numerous, all entire, linear-lanceolate, subsessile, attenuate to an acutish apex, 3-nerved, glabrous, mostly 3 to 5 cm. long; spikes dense, 2 to 10 cm. long, the axis pubescent; bracts dull purplish, relatively shorter and broader than the leaves, mostly entire, only the uppermost lobed, more or less puberulent; calyx tubular-campanulate, puberulent, about 12 mm. long, cleft for about half its length before and behind, each lobe cleft to about the middle, thus forming four acutish subequal teeth; corolla 18 to 20 cm. long, dull purple excepting the back of the galea, the latter straight, puberulent, equaling the tube, the lip very small, thick, saccate, protuberant, its slender subequal teeth acute.

Well distinguished by its entire leaves, creeping rootstocks, and dull-purplish spike. The flowers resemble closely those of *C. oreopola subintegra* Fernald, but that has clustered stems.

A characteristic species of the Darlingtonia swamps of Josephine County, Oregon.

Type specimen.—Sheet no. 528,817, U. S. National Museum.

Collected 8 miles south of Waldo, June 14, 1904, by C. V. Piper, no. 5097. Cusick's no. 2944, collected in boggy meadows of the Illinois River in Josephine County, is the same species, but with a somewhat more pubescent inflorescence.

VALERIANA PUBERULA Piper, sp. nov.

Erect, from stout creeping rootstocks, 30 to 40 cm. high; herbage puberulent throughout; leaves mostly basal, 5 to 8 cm. long, usually lyrate, 3 to 7-lobed, the terminal lobe oblong or obovate, with a few coarse teeth, the lateral lobes narrowly oblong and entire; cauline 2 or 3 pairs, the upper much reduced, the lobes linear-oblong, more conspicuously toothed; cymes contracted, simple, or occasionally two smaller ones from the axils of the bracts; these linear-lanceolate, entire or toothed; bractlets sessile, lanceolate, hooded at base, attenuate-acute; corolla 3 mm. long, white, short-funnelform, slightly gibbous at base, its lobes obtuse, shorter than the tube; stamens protruding, the slender filaments glabrous; ovary oblong-ovate, glabrous, the stigma slightly 3-lobed.

Collected at the base of Castle Crest, Crater Lake, Klamath County, Oregon, August 1, 1897, by Frederick V. Coville and Elmer I. Applegate, no. 340.

Type specimen.—Sheet no. 380,552, U. S. National Museum.

Closely related to *V. sitchensis* Bong., but at once distinguished by its puberulence.

CONTRIBUTIONS TO THE STUDY OF THE CANYON DIABLO METEORITES

By GEORGE P. MERRILL and WIRT TASSIN
Of the Department of Geology

Part I

By GEORGE P. MERRILL

Attention was first called to the remarkable distribution of meteoric irons in the vicinity of Canyon Diablo, Coconino County, Arizona, at the 1891 meeting of the American Association for the Advancement of Science, held in Washington.[1]

Since that time the physical and chemical characteristics of the irons have been described by numerous workers, including Huntington,[2] Cohen,[3] Brezina,[4] and Derby,[5] while others have discussed the subject with reference to the occurrence of diamonds in the iron, the origin of the crater, etc.; these papers, for the present, need only incidental reference. The matter will be taken up more in detail in a final paper which is in process of preparation.

Interest, almost to the point of sensationalism, has recently been revived in the occurrence through the publication of Messrs. D. M. Barringer and B. C. Tilghman,[6] of Philadelphia, who have shown the meteoric hypothesis of the origin of the crater to have had a much more substantial basis than many, including the writer, were at first disposed to admit. Correspondence and interviews with the writers of this paper led to the acceptance on the part of the present writer of an invitation to visit the crater, and the placing in his hands, for study, of a complete series of the meteoric products and other materials found associated therewith. One of these products, an altered sandstone, has been already described.[7] The present paper

[1] Proc. Am. Assoc. Adv. of Sci., August, 1891, p. 277; Am. Jour. Sci., vol. 42, 1891, p. 413.

[2] Am. Acad. Arts and Sciences, vol. 22, 1892, and 1894.

[3] Meteorischen Studien, IV, 1895.

[4] Die Meteoritensammlung des k. k. Nat. Hof. Mus., 1895.

[5] Am. Jour. Sci., vol. 49, 1895, p. 101.

[6] Proc. Acad. Nat. Sci. Phila., December, 1905.

[7] A Peculiar Form of Metamorphism in Sandstone. Proc. U. S. Nat. Mus., vol. XXXI, 1907, p. 547.

has to do principally with a singular type of meteoric iron which for evident reasons was overlooked by earlier observers.

In stating the facts bearing upon the origin of the crater, Mr. Barringer[1] writes of disinterring from pits and open cuts numerous nodular masses of oxidized meteoric material, or "shale balls" of all weights up to fifty pounds. These were usually roughly globular in outline, and consisted exteriorly of hydrated oxide of iron which served as a cement, loosely binding together the adjacent rock fragments (see pls. XVIII and XIX). In a number of instances such were found to contain still unoxidized iron centers or nuclei, the intermediate zone showing a green hydroxide of nickel mingled with oxides of iron. Several of these "shale balls" were given the writer for examination and study, and it is to them in particular and their bearing upon the problem that the present paper has reference.

The occurrence of the balls is sufficiently described in the paper of Mr. Barringer. The writer, while on the ground, saw several of them exhumed, and can corroborate his description in every detail. It will be well, incidentally, however, to emphasize the fact that the balls with iron centers have been found mainly on the north side of the crater and in the trenches, rarely on the surface.[2] The apparent significance of this will appear later.

The appearance of the freshly exhumed shale ball is that of a rough and friable mass of iron oxide encrusted with bits of sandstone and limestone, and in the case of those found but a short distance below the surface, thickly entangled with grass roots (pl. XVIII, fig. 1).

In the case of the smaller, superficial masses, oxidation has usually progressed to the extent that no metallic residue remains, and the nodule quickly falls to pieces on exposure. The larger and deeper-seated nodules, as their weights indicate, still retain unaltered nuclei. Such, cut in halves, are shown in fig. 2, pl. XVIII, and figs. 1 and 2, pl. XIX. The rounded mass of iron is surrounded by a crust of oxide, some 10 to 15 mm. in thickness. Mr. Tassin's examinations show this oxide to consist of both limonite and turgite. Beyond this is an indefinite zone of iron oxide and rock fragments. The inner zone of oxide is identical in composition and physical properties with much of the iron shale so common on the surrounding surface, and suggests at once a like origin for both. An etched surface of the

[1] Proc. Acad. Nat. Sci. Phila., 1905, pp. 878, 879.

[2] Since the above was put in type Mr. Barringer has informed the writer that one shale ball has been found on the east side of the crater, and one completely oxidized form on the south.

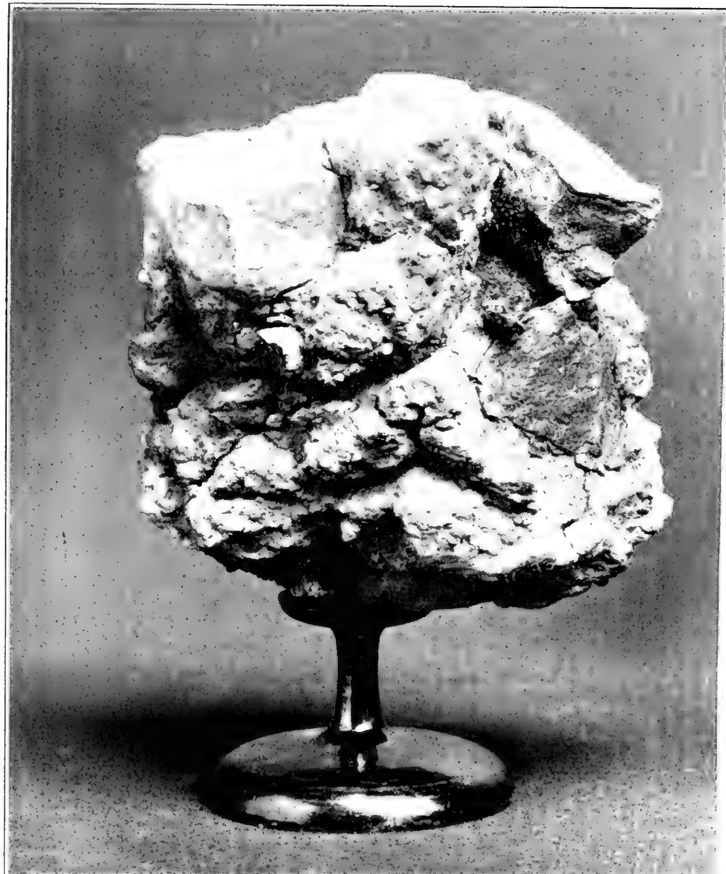


FIG. 1

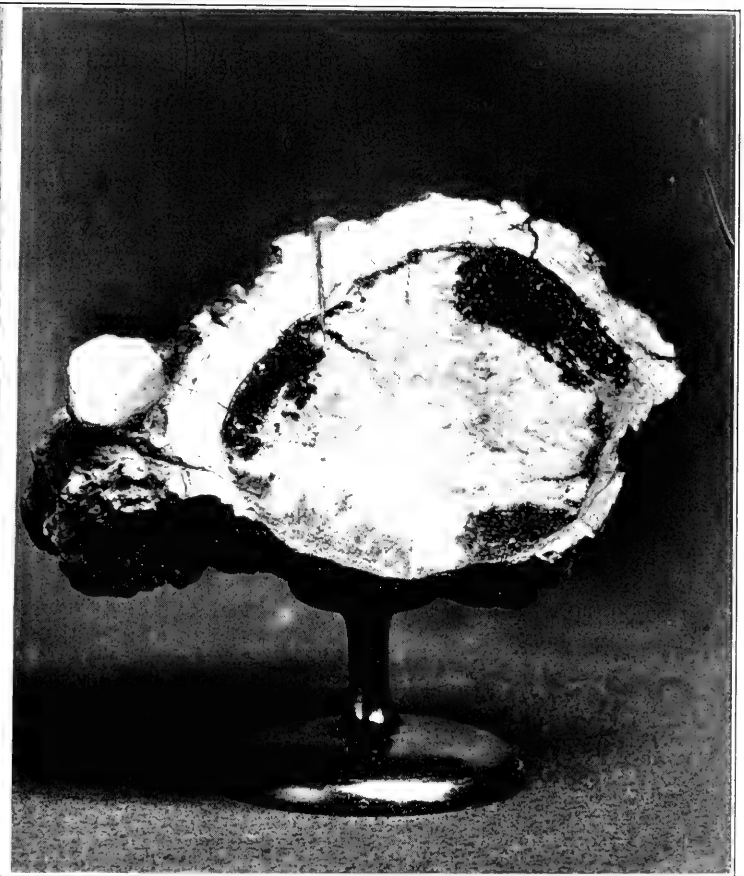


FIG. 2

CANYON DIABLO METEORITES

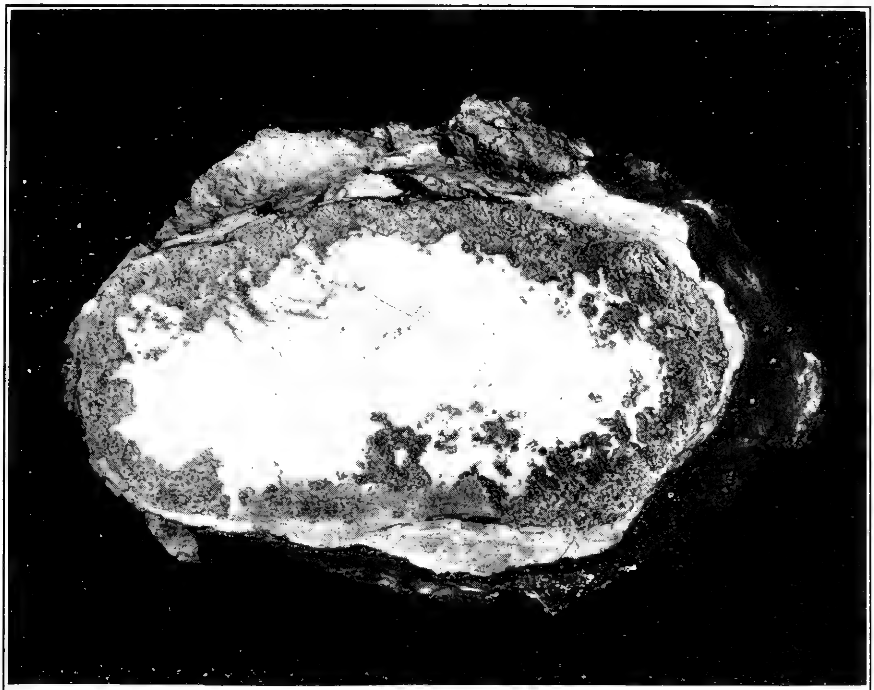
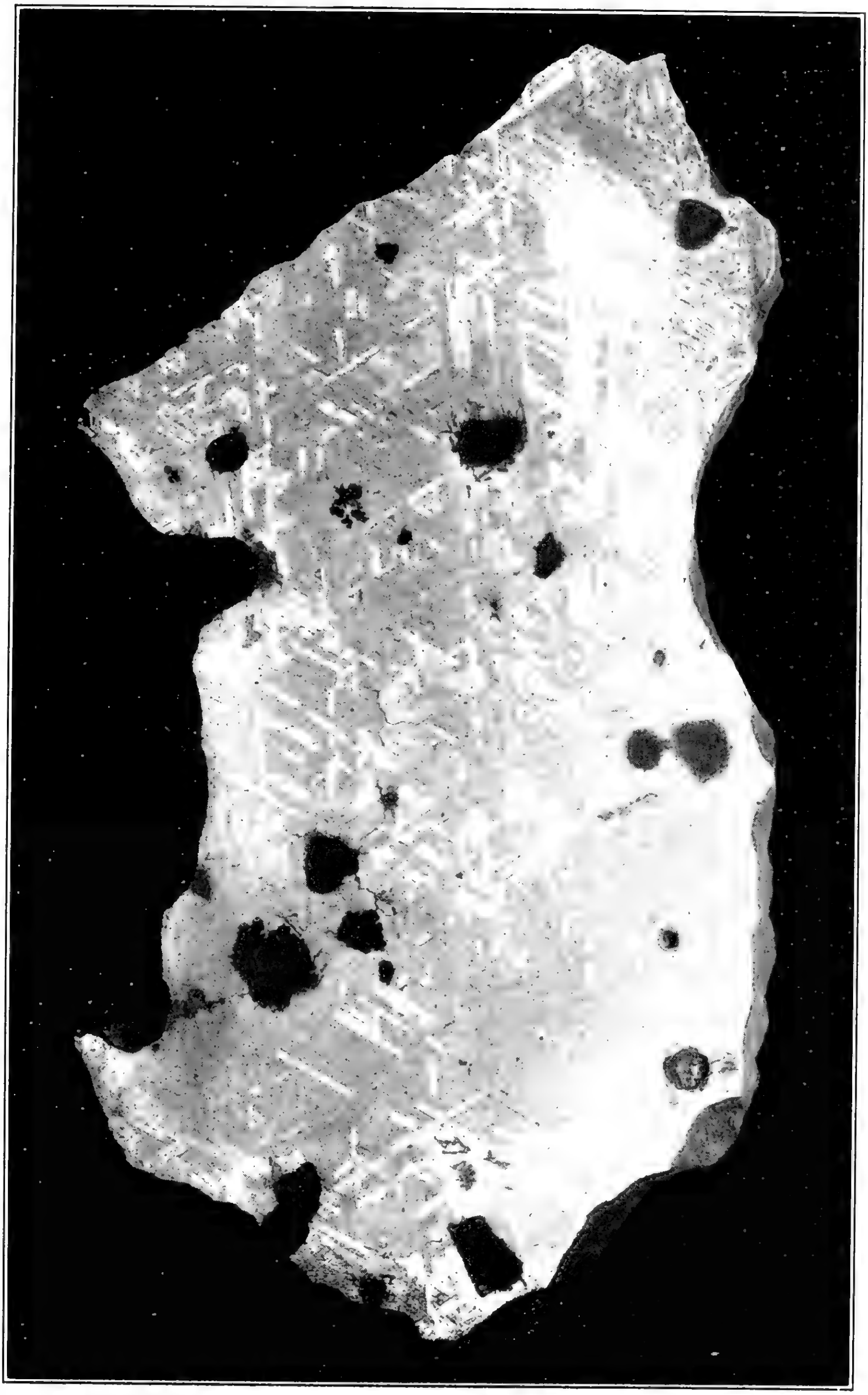


FIG. 1

FIG. 2

CANYON DIABLO METEORITES



CANYON DIABLO METEORITES

unaltered iron shows a structure quite unlike that of the typical iron, as described (see pl. XX), a difference so striking that one unacquainted with the conditions under which they were found would certainly be justified in pronouncing them independent falls. This difference, which is further accentuated in composition, as shown in Mr. Tassin's paper (p. 209), is very evident in the illustrations (compare pls. XIX and XX).

As noted by Mr. Tassin and as is readily evident on even a casual inspection, the shale iron differs from the other irons in the relatively large proportion of iron chlorides and phosphides and in the lack of the broad kamacite plates so conspicuous in pl. XX. So abundant are the first mentioned that a polished surface soon tarnishes, the chloride, as is usual in chloride-rich irons, exuding in the form of greenish drops which quickly oxidize, coating it with a layer of "rust." Fig. 2 of pl. XVIII and fig. 1 of pl. XIX show polished surfaces with oxidized coatings produced by an exposure of but a few days in the atmosphere of this office. The common type of the Canyon Diablo iron (pl. XX), on the other hand, is very stable, withstanding the warm, damp atmosphere of Washington, for a prolonged period without serious oxidation.

The writer believes that the discovery of these shale balls explains the origin of the widely disseminated iron shale which is found on the plain and which has been the subject of discussion by other writers, particularly Derby,[1] Barringer,[2] and Farrington.[3]

The explanation now given is not new or, at least, not wholly so, but is emphasized here and apparently substantiated by the finding of the shale actually in contact with an unaltered nucleus and in process of formation. The shale, according to this view, originates through the oxidation of a peculiarly susceptible variety of the iron and is not to be explained, as does Dr. Farrington, on the basis that such were derived from buried irons, which would receive a larger amount of water from being covered with soil and rock fragments, and hence would oxidize more rapidly. That, however, the protective covering was instrumental in producing this particular type of shale is probable, since the gradually oxidizing material would be held in place rather than fall away to powder, as would be the case if the decomposition took place on the surface.

The presence of the shale scattered so widely over the plain, usually in fragments rather than in the form of balls with metallic nuclei, the writer would explain as follows:

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[1] Am. Jour. Sci., vol. 49, 1895, p. 102.
[2] Proc. Acad. Nat. Sci. Phila., December, 1905, p. 879.
[3] Am. Jour. Sci. (4), 17, 1907, p. 300.

It must be remembered that this fall is very old; just how old it is impossible to say, but on the now apparently plausible assumption that it was contemporaneous with the formation of the crater, it must antedate the latest eruption of the volcanoes north of Flagstaff, since, as Mr. Tilghman informs me, the borings have shown that the fine lapilli, scattered universally over the plain, occur likewise over the bottom of the crater. This places it back several hundred years at least. During this period the general surface of the plain must have been cut down appreciably, both by wind and water action, and the irons and heavier pebbles and boulders are thus left exposed.

Dr. Farrington's statement[1] that the meteoric irons "are found only at the surface" is, if not founded upon a misapprehension, at

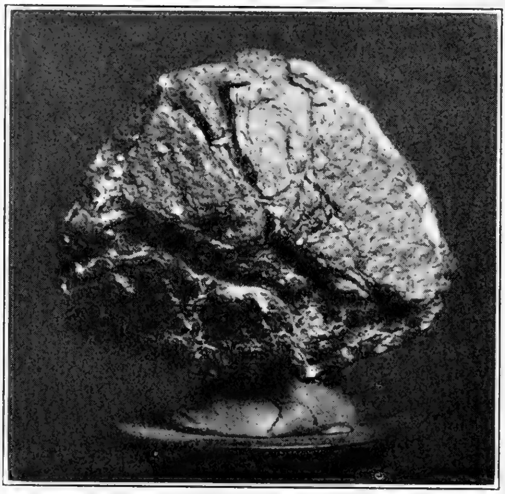
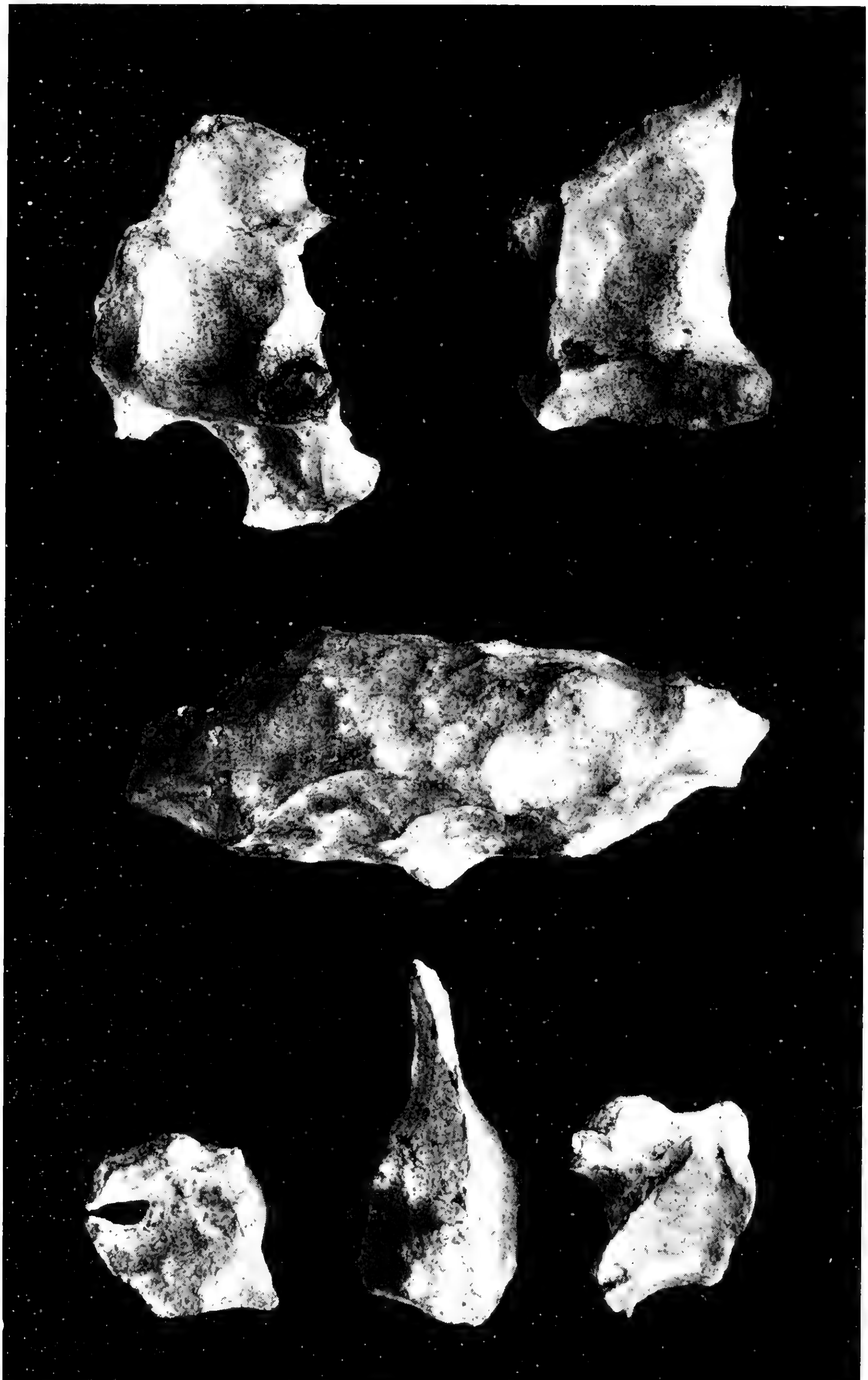


FIG. 48

least misleading. It is true that those thus far found lay on or near the surface, but this the writer believes is due to their having been uncovered by erosion. As a matter of fact, nearly all—even those of but a few ounces in weight—are still covered by earth, with only a mere point of iron projecting, and one not experienced in finding them may pass repeatedly over a given area without success, while the experienced will pick them up almost under his very eyes.

The shale balls, in varying stages of formation and destruction, are thus gradually brought to light, and, no longer confined by the compact envelope of earthy matter, go quickly to pieces, and no recognizable trace of the metallic portion remains.

[1] Am. Jour. Sci. (4), 17, 1907, p. 308.



CANYON DIABLO METEORITES

There are yet to be considered in this connection the small pear-shaped and oval balls of oxide which have been found by Mr. Barringer and others far out on the plain and wholly independent, so far as locality is concerned, of either the shale ball just described or the irons. These, as shown in text figure 48, are, as a rule, more or less flattened and with surfaces much checked. Exteriorly they are composed of platy iron oxide indistinguishable, either chemically or physically, from that of the typical shale balls. These were considered by Mr. Barringer as solidified drops of fused oxide stripped off from the main mass by atmospheric friction.[1]

Several of these forms were found by the writer, and other more typical forms were generously placed in his hands by Messrs. Barringer, Tilghman, and Holsinger. These have been cut in halves by a diamond saw and have been found in their more solid parts to retain still recognizable traces of the original crystalline structure of the iron, and also still unoxidized particles of iron phosphides. But it has been shown by Berwerth[2] and Mr. Tassin's work in the Museum laboratory that the heating of meteoric iron, even at a temperature far below the point of fusion, completely changes its structure. We are forced to conclude therefore that these forms are also products of terrestrial oxidation of small sulphur-chlorine-rich individuals once buried in the soil, but in which the material, before exposure by erosion, had so far adjusted itself to atmospheric conditions that no subsequent disintegration has taken place.

There remains for the present to be discussed only the relationship in origin between these chlorine-phosphorus-rich varieties and the normal irons.

As is well known, the fall is remarkable for the large number—several thousand at least—of independent individuals which have been found, and which show no evidence of atmospheric friction such as is common to meteorites, and by which one is enabled to judge of their orientation during the latter part of their flight through the air.

Such forms as those shown in pl. XXI, for instance, could not have escaped the loss of some of their exposed edges and points had they, unprotected, been subjected to any long frictional action. Yet these are no exception to the rule, sharp angles prevailing, and the individual irons showing further no torn nor broken edges such as to suggest that they once formed portions of a larger mass.

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[1] Such an origin would apparently have been considered as possible by Lockyer. See his Meteoric Hypothesis, p. 69.

[2] Sitz. du Kaiserl. Akad. der Wiss., v. CXIV, 1905, p. 345.

An attempt has been made by at least one writer to account for these forms, some of which are of not over a gram in weight, on the supposition that they were flaked off from the cold parent mass through the superficial heat suddenly developed after the meteorite entered our atmosphere. It is, perhaps, not safe, without experimental work, to say how a mass of iron might behave under these conditions. It should be borne in mind, however, that the Canyon Diablo iron is one of the hardest and toughest of known meteorites, and that, moreover, as has been apparently definitely shown, the depth of the penetration of heat in such cases is extremely slight, owing to the rapid stripping off of the burned or fused material during its passage through the air. The discovery of this readily oxidizable variety of what is apparently a part of the same fall[1] may, perhaps, enable us to account for this phenomenon otherwise.

The possibility of the irons being but residuals out of a large and coarse-grained stony meteorite or pallasite has often been considered by the writer and is discussed by Mr. Barringer. He fails to find any evidence in favor of such a supposition. With these conclusions the writer agrees. In comparing the large number of irons which the Messrs. Barringer and Tilghman have placed in our hands we think, however, we have been able to trace a tendency toward gradation of one form into another. In cutting several which seemed nearly identical with the well-known types, we found here and there apparent intermediate structures (see upper right of pl. XX), and portions rich in iron phosphide, with thin particles of shale adhering. We have therefore come to the conception of a large heterogeneous mass of nickel-iron with segregation masses rich in chlorides, phosphides, and sulphides. Such would naturally rupture most readily along the line of contact with the more homogeneous portions, and, moreover, the results of atmospheric frictional heat would ignite and burn away the sulphide portions. Even where the heterogeneous masses of considerable size fall to the earth it is possible that these susceptible portions would oxidize and wholly disappear, leaving the more refractory to be found later. This would account for the almost constant association of shale and irons of the type shown in pl. XXI at various points out on the plain.

The occurrence of the still incompletely oxidized forms—shale balls—as described, is due to the protective action of the dry soil in a region of great aridity, the annual precipitation, as recorded by the Weather Bureau, being but about 8 inches. It has been shown by the Bureau of Soils that under such conditions soils rarely or never become saturated with moisture for more than a few inches below

[1] The possibility of an independent fall has been considered.

the surface, and that this moisture is brought back by capillarity and evaporated rather than drained off at lower levels, as in more humid regions. An iron thus buried, even though rich in chloride and sulphide, would therefore endure for a long period.

PART II.

By WIRT TASSIN

A. THE SHALE-BALL IRON

Several sections of the "shale balls" having iron centers were polished and etched. These etched surfaces were apparently so different in appearance from the ordinary Canyon Diablo irons that had their locality not been known they would not have been regarded as parts of the same fall. Sections of the Canyon Diablo meteorite, which had been in the possession of the Museum since 1894, were found which showed areas having the usual very coarse octahedral structure, with broad kamacite plates, together with small areas having a structure closely comparable with those of the shale-ball irons (pl. XX). Further, the analysis of the shale-ball iron compared with those of the well-known Canyon Diablo agrees as closely as could be expected in a heterogeneous mass subject to segregation. Thus:

Constituents.	A.	B.	C.	D.
Fe	95 370	91.396	93.510	94.030
Ni.	3 945	7 940	5 600	5 320
Co	......	......	0.044	0.020
Cu	......	......	trace	0.010
P.	0 144	0 179	0.156	0 235
S.	trace	0.004	0.010	0 005
C.	......	0 417	0.512	0.121
Si.	trace	0.047	0.050	0.020
Cl.	......	......	0.000	0.120
Insol	0.260	......	......	......
Total	99.719	99.983	99 882	99 881

Analysis "A" was made by Moissan,[1] "B" by Booth, Garrett, and Blair,[2] "C" and "D" by myself. The analyses "A" and "B" were made prior to the discovery of the shale-ball irons, and, like "C," which was made on an iron collected by Mr. G. K. Gilbert in 1892, are of Canyon Diablo irons of the ordinary type. "D" is that of a shale-ball iron. It will be noted that "A," "B," and "C" are distin-

[1] Compt. Rend., 1904, CXXXIX, 776.
[2] Proc. Phila. Acad. Sci., 1905, LVII, 875.

guished by the absence of chlorine, and in "C" at least this element was especially looked for, while "D" contains 0.120 of a per cent; also that the amount of phosphorus in "D" is much greater than in the others. To this difference in the chlorine and phosphorus content is due the difference between the two types of iron in their degree of oxidation, and to a certain extent their difference in structure.

The surface developed by etching a polished section of a shale-ball iron is characterized by the absence of the coarse lamellar structure with broad plates of kamacite, and by the presence of numerous schreibersite areas, more or less regularly arranged. Nodules of carbon and troilite are generally absent (see pl. XIX).

The mass of the etched area is seen to be made up of a darker-colored alloy, or eutectic (plessite), containing numerous masses or plates of schreibersite in parallel arrangement, oriented in the directions of the sides of triangles which correspond to three directions of the octahedron. These schreibersite areas are seldom less than a millimeter in width, and vary in length from two millimeters to thirty millimeters, with an average of about five millimeters.

Associated with and next to the schreibersite areas, and commonly bounding them along their longitudinal directions, may often be seen a more or less narrow band of cohenite. This cohenite area is more or less interrupted and has not been observed to form a continuous border to the schreibersite. Only occasionally has the cohenite been seen independently of the schreibersite, and then only in very small quantities. Small areas of kamacite may also be seen in the eutectic. These kamacite areas occur very sparingly and are rarely over a millimeter along their maximum diameters. Bounding the kamacite is a very fine hair-like line of a tin-white alloy which is regarded as tænite. This alloy occurs elsewhere apparently not associated with kamacite and seemingly developed in thin plates or sheets along the planes of irregular and much-interrupted octahedral cleavages of the eutectic, and which have an orientation identical with that of the schreibersite masses as above mentioned. Further, the tænite may occasionally be found arranged concentrically and outside of some of the smaller schreibersite masses at a distance of about a millimeter therefrom.

Troilite was not observed as visible segregations in the section under discussion, but under the microscope its presence was occasionally shown by treating the eutectic with an acid and cadmium chloride.

Carbon, as graphite, diamond, or in the amorphous form, could not be detected. The above statement is also true of lawrencite, although the iron oxidizes, with extreme ease and a very short exposure to the atmosphere of the room, will cause it to sweat (fig. 2, pl. XIX).

A metallographic description of the eutectic itself cannot satisfactorily be made, since it was found almost impossible to resolve it under the microscope. Practically all that can be said is that the darker-colored alloy is fine granular; that the grains are apparently homogeneous, and are probably made up of minute octahedra arranged in very fine lamellæ.

The mineralogical separations made on the shale-ball iron did not yield the varied material that the ordinary Canyon Diablo irons have

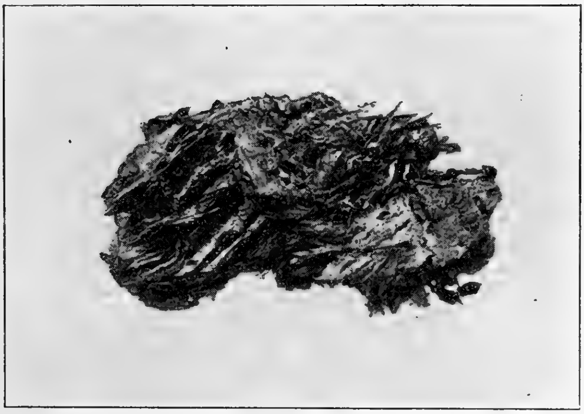


FIG. 49

yielded. Troilite, magnetite, chromite, diamond, and graphite were not found.

Schreibersite occurs abundantly in three distinct forms. The most common occurrence is as broad, thin, dark steel-gray, flexible magnetic lamellæ. These are often felted together to such an extent that in one case a mass of them weighing 26 grams has been preserved intact (text fig. 49). They have a specific gravity of 7.090 and the following composition:

P	13.80
Fe	63.04
Ni	23.07
Co	0.03
Cu	0.00

The second occurrence of this phosphide is as more or less flattened and angular nodules and rounded grains having a brilliant steel-gray to nearly tin-white color, quite brittle and strongly magnetic. Their specific gravity is 7.20, and on analysis gave:

P	15.370
Fe	58.540
Ni	26.080
Co	0.052
Cu	trace.

The third form of the phosphide is as the lath-shaped form called rhabdite. This form occurs very sparingly free, and not enough of it was secured to do more than make a qualitative test to prove its identity. It is abundant as a constituent of the schreibersite lamellæ, and under the microscope, using a vertical illumination, the characteristic flat prisms are readily seen. In addition to the above forms of schreibersite, there is left a black non-magnetic residue having the following composition:

P	8.77
Fe	84.29
NiCo	5.00
C	2.16

Very little can be said concerning this material except that it may be a decomposition product resulting from the prolonged treatment of schreibersite with dilute acid.

Cohenite occurs in thin plates and rounded grains, none of which show any evidence of crystallization. When fresh, the mineral is dull tin-white in color, but soon changes to a bronze-yellow. The material analyzed contained some schreibersite, as shown by the phosphorus content. Its density was 7.612 and had the following percentage composition:

Fe	91.290
Ni	2.480
Co	0.100
C	5.960
P	0.015

The nickel-iron alloy, tænite, occurs as very thin tin-white flexible lamellæ having a brilliant metallic luster. An analysis gave:

Fe	72.160
Ni	27.750
Co	0.020
Cu	0.000
P	0.045
C	0.120

A small amount of olivine was noticed as occurring in rounded grains of a pale greenish-yellow color having the following composition:

SiO_2	41.51
MgO	52.70
FeO	5.89
NiO	0.29

B. The Iron Shale

That the oxidized portions of the shale balls (pl. XVIII, fig. 2) and the pear-shaped schistose masses of iron oxide shown in fig. 48 are the result of weathering subsequent to the fall of the mass, as stated by Derby[1] and Farrington,[2] does not seem to me to be open to question when their field occurrence is known. That both have the same origin is to me demonstrated by the following analyses:

Constituents.	A.	B.	C.
Fe_2O_3	74.63	78.82	81.07
FeO	3.91	0.65	0.00
NiO	9.79	8.85	4.66
CoO	0.49	0.39	0.00
CaO	1.27	0.00	0.00
MgO	0.00	0.02	0.00
H_2O	8.02	10.00	12.81
SiO_2	1.09	0.76	1.47
CO_2	0.35	0.00	0.00
Al_2O_3	0.05	0.00	0.00
S	trace	0.01	0.00
P	0.10	0.20	0.09
Cl	0.08	0.031	0.00
C	0.15	0.100	0.00
	99.93	99.831	100.10

CuO, SO_3 and P_2O_5 absent.

Analysis "A" was made by Mr. H. W. Nichols,[3] "B" and "C" were made by me; "B" on one of the inner layers of a shale ball having an iron center; "C" on a shale ball similar to that shown in fig. 49.

These analyses, which while in the aggregate are alike, differ in certain particulars to which attention should be called. Thus, Nichols finds 3.91 per cent of FeO; I find but 0.65 per cent in that made

[1] Am. Jour. Sci., 1895, 3d series, vol. 49, p. 101.
[2] Am. Jour. Sci., 1906, 4th series, vol. 22, p. 309.
[3] Am. Jour. Sci., 1906, 4th series, vol. 22, p. 306.

on the shale ball having an iron center, and none in that of the shale found on the plains. Farrington, combining his analysis, finds 42.39 per cent of magnetite, basing his figures upon the assumption that the protoxides of iron and nickel are so combined, and thus accounting for the magnetic character of the shale. I find no protoxide of iron in "C," and therefore have no reason for assuming the presence of magnetite in that case, at least. I am inclined to regard the iron shale as being made up essentially of limonite with some turgite, basing my opinion upon the physical characters of the shale in preference to data derived from combining the results of the analyses—a method admittedly speculative. Further, in the portions analyzed by me the magnetic character of the material is certainly due in part at least to the relatively large amount of unaltered schreibersite present and which is plainly visible in many sections of the iron shale.

EXPLANATION OF PLATES

Plate XVIII

Fig. 1. A typical "shale ball," consisting of a residual nucleus of metallic iron surrounded by a crust of iron oxide, to which are adhering fragments of sandstone and limestone. The crust has been broken away at the right just above the center, exposing a portion of the nucleus. (Cat. No. 76,843, U. S. N. M.)

Fig. 2. A shale ball similar to that shown in Fig. 1 cut in halves, showing the metallic nucleus with its crust of "iron shale." The dark marginal areas are due to the exudation and oxidation of iron chloride after cutting. (Cat. No. 76,842, U. S. N. M.)

Plate XIX

Shale ball cut in halves to show structure of the metallic nucleus and to illustrate the rapid oxidation which takes place along the outer margin. In the plate the two halves are oriented as laid open by the saw, the oxidation products and adhering rock fragments having broken away somewhat unequally. The outline between the metallic and oxidized products is very conspicuous. Fig. 1 shows a freshly polished surface, while Fig. 2 shows the second half after being for some days exposed to the air. The illustration shows the rapidly oxidizing ferrous chloride as it exudes around the outer margin. (Cat. No. 76,946, U. S. N. M.) Dimensions of metallic nucleus, 88 millimeters by 187 millimeters.

Plate XX

Etched slice of the common type of Canyon Diablo iron, showing the thick plates of kamacite and nodules of troilite. At upper right a small area of transition toward the structure of the shale ball iron. (Cat. No. 85,833, U. S. N. M.)

Plate XXI

Six characteristic pieces of the smaller Canyon Diablo irons of the common type, selected to show forms and lack of fusion effects on sharp angles. All reproduced on same scale. Actual length of central specimen, 170 millimeters. (Cat. No. 76,841, U. S. N. M.)

LOUIS AGASSIZ[1]

By CHARLES D. WALCOTT

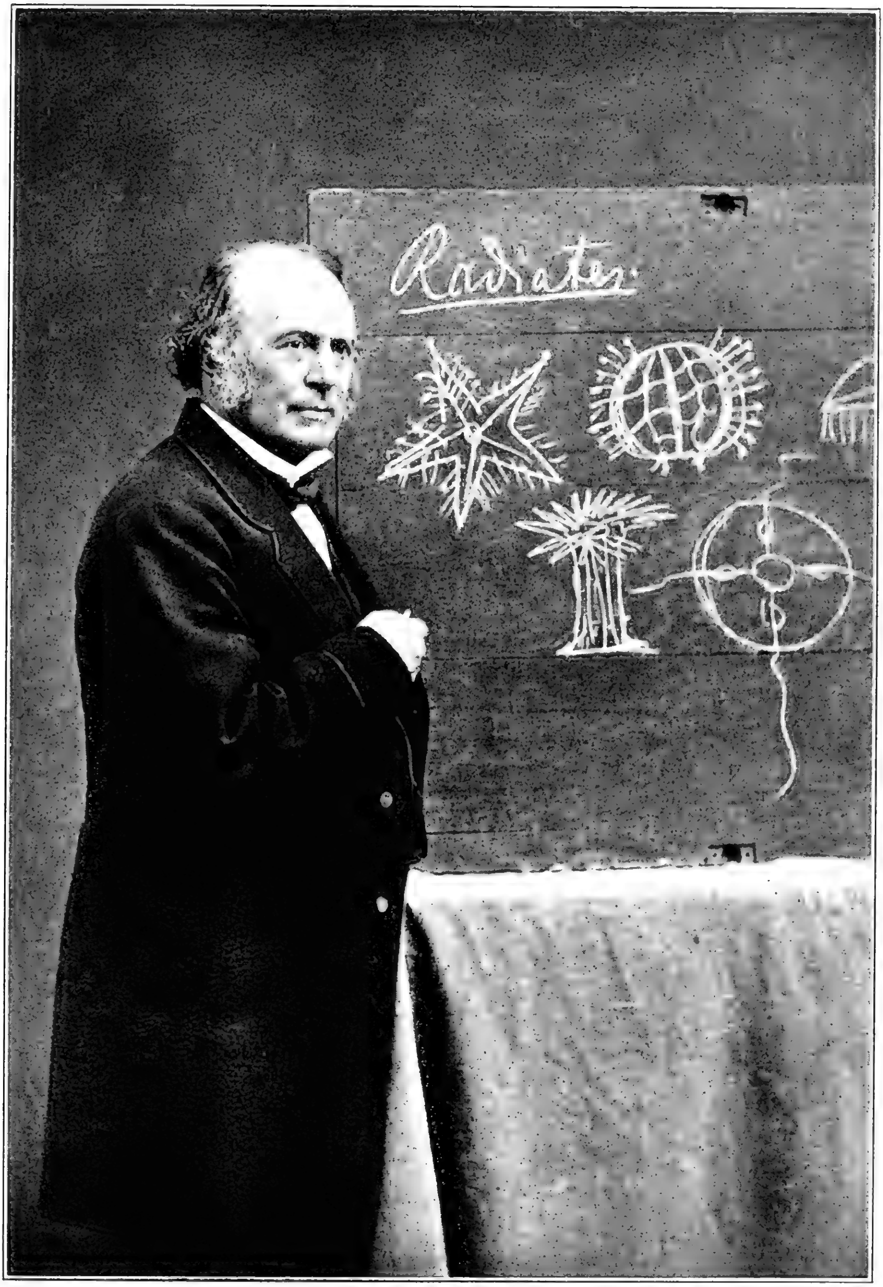
Louis Agassiz was a man of simple but intensely active life. Coming to us in 1848 for a special purpose, he met with so cordial a reception that flattering offers from European institutions could not induce him to return; and, although such a life as his cannot be limited by boundaries of space or time, we feel a peculiar pleasure and satisfaction in placing his name among those of our great men in this our Hall of Fame.

Agassiz was not only a pioneer in scientific investigation and achievement, but one of the first to combine the qualities of a great naturalist, leader of men, and lover of the masses of the people. We sometimes forget that many of the fundamental conceptions which underlie so much of the science of today are the products of his genius and the fruitage of his many years of labor. He taught American students how to think in terms of science, and he taught the American nation that to science it owed good will and cordial support.

Few men have lived who combined such breadth of intellect with such a fascinating personality, such genuine sincerity, such openness and warmth of manner, such depth of religious nature, such perfect unselfishness, and such devotion to science.

To Agassiz nothing was commonplace. He marshalled facts and ever kept them at command in the hope that they might throw light on some one of the great problems which he realized were to press more and more insistently for solution. The enduring value of his contributions to science is due to the soundness of the principles underlying them. At twenty-two years of age, Martius recognized his rare ability by allowing him to edit a volume on Brazilian fishes, and at twenty-five Cuvier transferred to him the treasures he had gathered for his work on fossil fishes. This early recognition stimulated him greatly and led him to master every subject that he undertook to investigate. Some one has said respecting him, that there never was a man with an "intellect more thoroughly disciplined

[1] Tribute to the memory of Agassiz at the unveiling of the Agassiz bust and tablet in the Hall of Fame, New York University, May 30, 1907.



LOUIS AGASSIZ

or less hampered by the abundance of the material on which it worked."

Agassiz's extraordinary geniality and the sincerity of his manner drew every one to him. The acknowledged leader of a group including Emerson, Holmes, Lowell, Longfellow, and Hawthorne, he was the friend of laborers and fishermen, who took a childish delight in gathering specimens for the "Great Professor." He measured men by a high standard, and created a new environment for himself. Those who loved him lived in mansions and in huts; he imbued the rich and the poor, the educated and the ignorant, alike with an appreciation of the beauties of the science he loved and with his almost matchless enthusiasm for the noble in life. In fact, it was as a leader of men, as the teacher of thousands who gained inspiration and power from his boundless enthusiasm and his loving personality, that he was most widely known.

Agassiz's life was a continual proof of his superiority over self-interest and his consecration to science. He declared that he could not afford to waste his time in making money. He declined the chair of Zoölogy at Heidelberg when by accepting it he would have more than doubled his income, and he successfully opposed the making of his name a part of the official designation both of the Museum of Comparative Zoölogy at Harvard and of the Anderson School of Natural History on Penikese Island. It would be difficult to measure his influence in the way of causing men of political and commercial power to realize that the support of scientific research and the diffusion of the knowledge thereby gained depend largely on them.

Men are now more and more contributing to the advancement of science under the impulse of a sentiment Agassiz created; he set a new standard for the art of teaching; the first recognition of ice as a great geologic agent was due chiefly to his investigations; and, as a result of his work on fossil fishes, there was established a fundamental law which has since found expression in the words "Ontogeny repeats phylogeny"—a law which, it would seem, is destined to guide biologists for numberless generations.

Many of us knew Louis Agassiz personally, perhaps a few of us knew him intimately, and our admiration of his genius and our love of the man were and are almost unbounded. Here in this noble building we now place a visible token of this nation's admiration of his great intellect, of its realization of the debt it owes him for his consecration to science, and of its love for his simple but sublime character, assured that the coming generations cannot fail to realize his claim to their regard as "the first naturalist of his time, a good citizen, and a good son, beloved of those who knew him."[1]

[1] From a letter written by Louis Agassiz to his father from Munich, February 14, 1829. See J. B. Marcou: Life, Letters, and Works of Louis Agassiz, I, 1895, p. 30; and E. C. Agassiz: Louis Agassiz, His Life and Correspondence, 1893, p. 98.

TERRESTRIAL ISOPODS OF THE FAMILY EUBELIDÆ, COLLECTED IN LIBERIA BY DR. O. F. COOK

By HARRIET RICHARDSON

Collaborator, Division of Marine Invertebrates, U. S. National Museum

Under the auspices of the New York State Colonization Society, a large collection of terrestrial isopods was made in Liberia during the years 1893 to 1895 by Dr. O. F. Cook, custodian of Myriapoda in the U. S. Department of Agriculture. Most of the specimens were collected at Mt. Coffee, at an elevation of three or four hundred feet. This mountain is just above the point of navigation of the Saint Pauls River. Other specimens were collected at Muhlenburg Mission, at Monrovia, and at Sierra Leone. The collections were made in the spring of the year, from January to May.

Through the kindness of Dr. O. F. Cook, the terrestrial isopods were given to me to study. I wish here to express my gratitude to Dr. Cook for this privilege. The present paper is the result of my study on one family in this collection, the *Eubelidæ*. All the specimens collected represent new species, and a new genus is added to the five genera already known.

It may be noticed that the general figures do not seem to correspond with the detail drawings. This lack of correspondence is due to foreshortening in the general figure, caused by the convexity of the specimens. The detail figures give a different perspective.

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FAMILY EUBELIDÆ[1]

Flagellum of second antennæ more or less obscurely triarticulate, rarely only biarticulate. Eyes distinct, composed of numerous ocelli. Inner lobe of the first or inner maxillæ furnished with numerous plumose processes (5-15). The first segment of the thorax has distinct epimera or coxopodites. Epimera or coxopodites generally present on the underside of the second and third segments.

The terminal abdominal segment is triangular at the base, with the apex triangularly or even quadrangularly produced in a process not extending, or extending very little, beyond the lateral parts of the preceding segment. Uropoda short, not extending, or extending very little, beyond the terminal segment of the abdomen. Basal article large, wide. Outer branch small or minute.

ANALYTICAL KEY TO THE GENERA OF LIBERIAN EUBELIDÆ

a.—Flagellum of second antennæ composed of three articles.
- *b.*—Coxopodites of first thoracic segment cleft posteriorly, a fissure separating the coxopodite from the post-lateral angle of the segment.
  Genus *Mesarmadillo*
- *b'.*—Coxopodites of first thoracic segment entire, without a fissure separating them from the post-lateral angles of the segment.
  Genus *Periscyphops*

a'.—Flagellum of second antennæ composed of two articles.
- *b.*—Coxopodites of first thoracic segment forming a wide border adjacent to and extending along the lateral margin of the segment.
  Genus *Ethelum*
- *b'.*—Coxopodites of first thoracic segment extending along the lateral margin, but arising from the underside of the segment
  Genus *Ethelumoris*, gen. nov.

Genus MESARMADILLO Dollfus

Mesarmadillo DOLLFUS, Annales de la Société Entomologique de France, 1892, LXI, pp. 385–386. BUDDE-LUND, A Revision of "Crustacea Isopoda Terrestria," pt. 1, Eubelum, 1899, p. 10.

Flagellum of second antennæ composed of three articles. Coxopodites of first thoracic segment extending along the lateral margin of the segment and adjacent to it in the form of a border, being

[1] For characters of family see Budde-Lund, A Revision of "Crustacea Isopoda Terrestria," 1899, pt. 1, Eubelum, pp. 2–3.

separated from the segment by a longitudinal groove. The lateral margin of the coxopodite is not sulcate. The coxopodites are cleft posteriorly, a fissure separating them from the post-lateral angle of the segment.

Epimera present on the second and third segments in the form of narrow ridges on the anterior portion of the underside.

Exopodite of the uropoda inserted about the middle of the posterior margin of the quadrangular basal article.

ANALYTICAL KEY TO THE SPECIES OF THE GENUS MESARMADILLO FROM LIBERIA

a.—Terminal segment of abdomen with apex produced in a process truncate at the extremity.

b.—With a marginal band of yellow surrounding the entire body. Length of apical process of terminal abdominal segment to width in ratio of 4½ : 2½ .... *Mesarmadillo flavimarginatus*, sp. nov.

b′.—Without a marginal band of yellow surrounding the entire body. Length of apical process of terminal abdominal segment to width in the ratio of 5 : 2½ .... *Mesarmadillo similis*, sp. nov.

a′.—Terminal segment of abdomen with apex produced in a process not truncate at the extremity.

b.—Terminal segment of abdomen produced in a process which has the sides converging gradually to a triangular extremity. *Mesarmadillo hastatus*, sp. nov.

b′.—Terminal segment of abdomen produced in a process which has the extremity rounded.

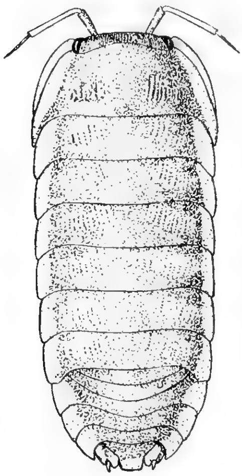
c.—Third and seventh thoracic segments with a large yellow spot on either side of the lateral margin. Apical process of terminal abdominal segment narrow. *Mesarmadillo quadricoloratus*, sp. nov.

c′.—Third and seventh thoracic segments without yellow spots. Color mottled, variegated. Apical process of terminal abdominal segment broad. . *Mesarmadillo variegatus*, sp. nov.

MESARMADILLO FLAVIMARGINATUS, sp. nov.

Body smooth, minutely punctate, contractile into a ball. Color, dark brown, with the lateral parts of all the segments light brown or yellow, so that a border of light brown completely encircles the body. The median dark area is slightly broken up on either side of the median longitudinal line by rather indistinct wavy lines of the lighter color. There is a small pearliform granulation on either side of each one of the thoracic segments.

The head is much wider than long, 3½ mm. : 10 mm. The frontal margin is straight. The eyes are small, round, composite, and situated at the lateral margins. The front of the head is not margined, but is continuous with the epistome, which is produced on the ventral side in a small tubercular-like convexity. The first pair of antennæ are small and inconspicuous. The second pair have the first article short; the second is twice as long as the first; the third is about as long as the second; the fourth is nearly twice as long as the third; the fifth is a little longer than the fourth. The flagellum is composed of three articles, the middle one of which is somewhat shorter than the other two.



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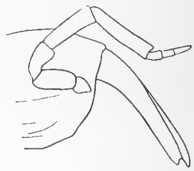

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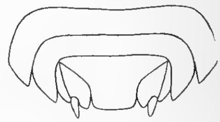

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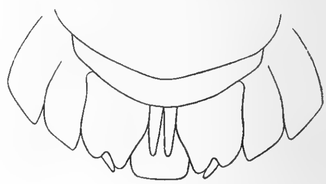

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FIG. 50.—*Mesarmadillo flavimarginatus,* sp. nov. General figure. × 3 2/5.

FIG. 51.—*Mesarmadillo flavimarginatus,* sp. nov. Coxopodite of first thoracic segment (dorsal view). × $9\frac{1}{3}$.

FIG. 52.—*Mesarmadillo flavimarginatus,* sp. nov. Coxopodite of first thoracic segment (lateral view). × $9\frac{1}{3}$.

FIG. 53.—*Mesarmadillo flavimarginatus,* sp. nov. Coxopodite of first thoracic segment (ventral view). × $9\frac{1}{3}$.

FIG. 54.—*Mesarmadillo flavimarginatus,* sp. nov. Last three segments of abdomen with uropoda. × $9\frac{1}{3}$.

FIG. 55.—*Mesarmadillo flavimarginatus,* sp. nov. Abdomen with uropoda (ventral view). × $9\frac{1}{3}$.

The first segment of the thorax is nearly twice as long as any of the others, which are subequal. The first segment is 8 mm. in length. The second is 4 mm. long. The coxopodites of the first segment form a rather wide marginal border, not extending quite to the post-lateral angles of the segment. A longitudinal groove separates them from the dorsal portion of the segment. There is no lateral groove. They are cleft posteriorly by a fissure not very deep and are unequally cleft, the inner portion being the smaller. Coxopodites are also present on the underside of the second and third segments at the anterior portion of the lateral margin in the form of thickened ridges, more acute and toothlike on the second segment.

The first five segments of the abdomen are about equal in length. The lateral parts of the first two are covered by the seventh thoracic segment. The lateral parts of the three following segments are well developed and extend backward, those of the fifth segment reaching the extremity of the basal article of the uropoda. The sixth or terminal segment is triangular at the base, with the apex produced in a widely quadrangular process, with truncate extremity and parallel sides. It is 4½ mm. long. The width of the apical process is 2½ mm. The width of the segment at the base is 7 mm. The basal articles of the uropoda occupy all the space between the apical process of the terminal abdominal segment and the produced lateral parts of the fifth segment and extend to the extremity of the apical process. The basal article is somewhat quadrangular in shape, with the posterior margin deeply excavate in the middle, on either side of which the post-lateral angles extend in the form of rounded lobes. Close to the external margin of the basal article is a well-defined and most-pronounced carina extending the entire length of the article. The outer branch of the uropoda is large, conical in shape, is inserted in the posterior excavation of the basal article, and extends half its length beyond the lateral angles. The inner branch does not reach by some distance the extremity of the terminal abdominal segment and is not visible in a dorsal view. All the legs are ambulatory.

More than forty specimens were collected by Dr. O. F. Cook at Mt. Coffee and Muhlenberg Mission. About ten more were collected by Mr. R. P. Currie, one by Mrs. Sharp, and one by Mr. Collins, in the same locality.

The type is from Mt. Coffee and is in the possession of Dr. O. F. Cook.

The co-type, collected at Mt. Coffee by Mr. R. P. Currie, is in the U. S. National Museum. Cat. no. 38,526.

MESARMADILLO SIMILIS, sp. nov.

Body ovate, a little more than twice as wide as long, convex, contractile into a ball. Surface smooth, with a small, pearliform granule on either side of each one of the thoracic segments. Color, brown, with wavy lines of yellow, on either side of the median stripe of brown. First two articles of the peduncle of the antennæ and the extremities of the fifth articles yellow.

Head much wider than long, 3 mm. : 10 mm. Front not margined, but continuous with the epistome, which is slightly convex. Eyes small, composite, and situated close to the lateral margin. First pair of antennæ inconspicuous and rudimentary. Second pair have the first article short; the second article is three times as long as the first; the third is slightly shorter than the second; the fourth is nearly twice as long as the third; the fifth is nearly one and a half times as long as the fourth. The flagellum is composed of three articles, the second one of which is the longest.

The first segment of the thorax is nearly twice as long as any of the following, which are subequal. The first segment is 7 mm. long. Each of the following segments measures 3½ mm. in length. The epimera or coxopodites of the first segment are in the form of a moderately wide and thickened plate on either side, and they are separated from the segment by a groove or suture. They do not extend the entire length of the lateral margin, not reaching the post-lateral angles of the segment by some distance. They are cleft posteriorly, being separated from the segment by a fissure, which is not very deep. The post-lateral angles of the segment are not rounded, but angular, and in the form of a right angle. The coxopodites of the second and third segments are in the form of a thickened ridge, on the anterior part of the underside of the lateral portion of the segment. This ridge is thicker on the second than on the third segment.

The first two segments of the abdomen have the lateral parts covered by the seventh thoracic segment. The lateral parts of the three following segments are well developed and are produced backward. The third and fourth segments are each a little longer than either one of the first, second, or fifth segments, which are subequal. The sixth or terminal segment is triangular at the base and has the apex produced in a long process, with parallel sides and truncate extremity. The length of this segment is 5 mm. The width of the apical process is 2½ mm. The width of the segment at the base is 7½ mm. The basal article of the uropoda occupies all the space between the apical process of the terminal segment and the lateral parts of the preceding segment. It extends to the extremity of the apical process as well as to the extremity of the post-lateral angle of the fifth segment. The posterior margin is notched about the middle for the reception of the outer branch of the uropoda. On either side of the notch the post-lateral angles extend in the form of rounded lobes, the inner one being much longer and wider than the outer one. There is a distinct carina, which extends longitudinally along the entire length of the basal article close to the outer margin.

The outer branch of the uropoda is rather large, and extends half its length beyond the post-lateral angles of the basal article. The inner branch does not reach by some distance the extremity of

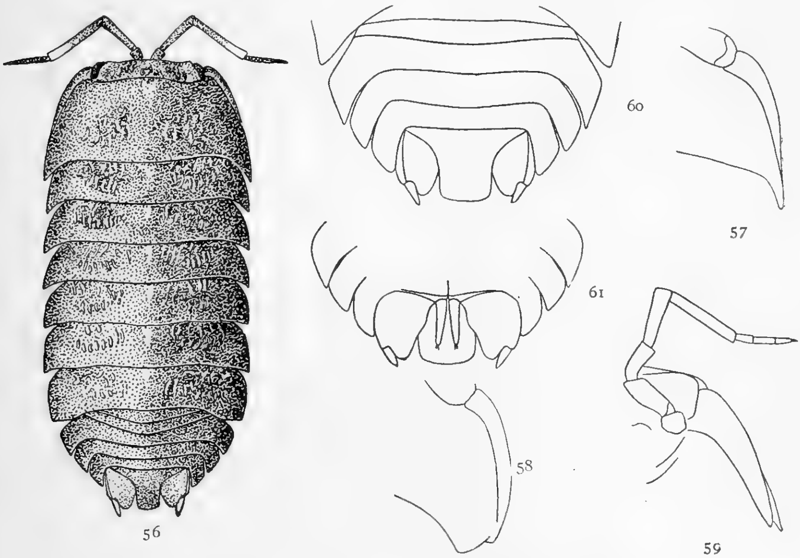


FIG. 56.—*Mesarmadillo similis*, sp. nov. General figure. × 3¾.
FIG. 57.—*Mesarmadillo similis*, sp. nov. Coxopodite of first thoracic segment (dorsal view). × 7.
FIG. 58.—*Mesarmadillo similis*, sp. nov. Coxopodite of first thoracic segment (lateral view). × 7.
FIG. 59.—*Mesarmadillo similis*, sp. nov. Coxopodite of first thoracic segment (ventral view). × 7.
FIG. 60.—*Mesarmadillo similis*, sp. nov. Abdomen with uropoda (dorsal view). × 7.
FIG. 61.—*Mesarmadillo similis*, sp. nov. Uropoda (ventral view). × 7.

the apical process of the terminal segment or the inner post-lateral angle of the basal article.

About twenty specimens of this species were taken at Monrovia by Dr. O. F. Cook. One specimen comes from Mt. Coffee. Another was collected by Rev. G. P. Goll at Muhlenberg Mission. This species is very close to the foregoing, and differs only in not having the band of yellow surrounding the entire body, so characteristic of the former, and in the longer apical process of the terminal abdominal segment. There is a distinct carina on the basal article of the uropoda, which is also present in *M. flavimarginatus,* but the post-lateral lobes of the basal article of the uropoda differ from those of *M. flavimarginatus.* These characters are not sexual ones, but are constant in both sexes of the two species.

The type is in the possession of Dr. O. F. Cook.

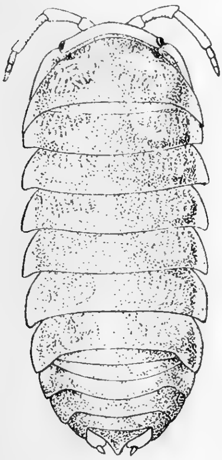
MESARMADILLO HASTATUS, sp. nov.

Body ovate, extremely convex, contractile into a ball. Surface smooth, punctate. Color, dark brown, with bands of wavy yellow lines on either side of the median longitudinal stripe of brown, and with the margins of all the segments, the uropoda, the coxopodites of the first segment, the head, and the antennæ all light yellow.

Head wider than long, 3 mm. : 9 mm., with the frontal margin slightly produced in the middle. Front not margined, but continuous with the epistome, which is convex about the middle. The eyes are small, composite, and situated at the lateral margins. The first pair of antennæ are small and inconspicuous. The second pair have the first article short; the second article is twice as long as the first; the third is as long as the second; the fourth is a little longer than the third; the fifth is a little longer than the fourth. The flagellum is composed of three articles, the first one of which is a little shorter than either of the other two, which are subequal in length.

The first segment of the thorax is nearly twice as long as any of the following segments, which are subequal. The first segment is 7 mm. long; the following six segments are each 4 mm. in length. The coxopodites of the first thoracic segment appear as wide and thickened plates extending along the lateral margin, but not reaching by some distance the post-lateral angles. They are separated from the segment by a deep, longitudinal groove, and are cleft posteriorly by a very shallow fissure, the inner portion being much smaller than the outer portion. Coxopodites are present on the anterior portion of the second and third segments on the underside in the form of thickened ridges, with crests sharply carinated.

The first two segments of the abdomen are covered laterally by the seventh thoracic segment. The lateral parts of the three following segments are well developed and are directed backward. The third segment is a little longer than the first, second, and fourth, which are subequal, and the fifth is slightly shorter. The sixth or terminal segment is triangular at the base and has the apex produced in a long triangular process, with sides converging gradually to an acute extremity. The basal article of the uropoda is large, somewhat quadrangular, and occupies all the space between the lateral angles of the fifth segment and the apical process of the sixth segment. It extends to the tip of the lateral angles of the fifth segment, but does not reach by some distance the extremity of the sixth segment. The posterior margin is excavate between the lateral angles, which are produced in lobes, the inner lobe being the longer. The outer branch of the uropoda is large, conical, and extends to the tip of the apical process of the sixth segment. The inner branch does not



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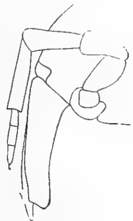

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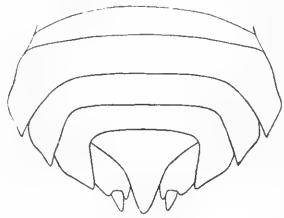

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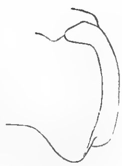

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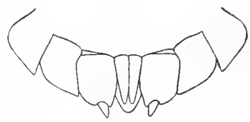

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FIG. 62.—*Mesarmadillo hastatus,* sp. nov. General figure. × 3.

FIG. 63.—*Mesarmadillo hastatus,* sp. nov. Coxopodite of first thoracic segment (dorsal view). × 7.

FIG. 64.—*Mesarmadillo hastatus,* sp. nov. Coxopodite of first thoracic segment (lateral view). × 7.

FIG. 65.—*Mesarmadillo hastatus,* sp. nov. Coxopodite of first thoracic segment (ventral view). × 7.

FIG. 66.—*Mesarmadillo hastatus,* sp. nov. Last five segments of abdomen with uropoda. × 7.

FIG. 67.—*Mesarmadillo hastatus,* sp. nov. Abdomen with uropoda (ventral view). × 7.

quite reach the extremity of the apical process of the terminal segment, but extends to the inner angle of the basal article of the uropoda. All the legs are ambulatory.

Three specimens of this species, two males and a female, were collected by Dr. O. F. Cook at Mt. Coffee. The type is in the possession of Dr. O. F. Cook. This species closely resembles *Mesarmadillo marginatus* Dollfus,[1] but differs chiefly in the length of

[1] Annales de la Société Entomologique de France, LXI, 1892, p. 387, pl. 7, figs. 2*a*, 2*b*.

the terminal segment, as compared with the uropoda, in the shape and length of the coxopodites of the first thoracic segment, in the antennæ, the fifth article of the peduncle in *M. marginatus* being much longer as compared with the previous article than in the present species and in the absence of the pearl-like granulation on each side of the thoracic segments, characteristic of *M. marginatus*.

MESARMADILLO QUADRICOLORATUS, sp. nov.

Body convex, contractile into a ball. Surface smooth, but with a small, pearliform granulation on either side of each one of the thoracic segments. Color, dark brown, with wavy lines of yellow on either side of the median line. There is a large spot on either side of the third thoracic segment on the lateral portion of the segment. On the seventh thoracic segment is a similar yellow spot, one on either side, close to the lateral margin. The basal article of the uropoda and the coxopodites of the first thoracic segment are also yellow, and in some of the specimens there are yellow spots in the median longitudinal line of the thorax.

Head wider than long, 3 mm. : 7 mm., with the frontal margin slightly rounded in the middle. Front not margined, but continuous with the epistome, which is slightly convex in the middle. The eyes are small, composite, and situated at the lateral margin. The first pair of antennæ are minute and inconspicuous. The second pair have the first article short; the second article is twice as long as the first; the third is as long as the second; the fourth is one and a half times longer than the third; the fifth is but little longer than the fourth. The flagellum is composed of three subequal articles.

The first segment of the thorax is nearly twice as long as any of those following, which are subequal. The first segment is 5 mm. in length. The second segment is 3 mm. long. The coxopodites form a rather wide lateral border on either side, wider anteriorly than posteriorly and not extending the entire length of the segment on the dorsal side, but almost to the post-lateral angles on the ventral side. The coxopodites are cleft posteriorly, the inner portion being smaller than the exterior portion. Coxopodites are also present on the anterior portion of the second and third segments in the form of a thickened ridge.

The first five segments of the abdomen are about subequal, the lateral parts of the first two being covered by the seventh thoracic segment. The lateral parts of the third, fourth, and fifth segments are well developed and directed backward. Those of the fifth segment extend about half the length of the basal article of the uropoda. The sixth or terminal segment is triangular at the base, with the apex produced in a long, narrow process, rounded at the extremity. The basal article of the uropoda is large, quadrangular in shape, and does not reach the extremity of the apical process of the sixth abdominal segment. The posterior margin is excavate, with the lateral angles produced on either side in rounded lobes. The outer branch is large, conical in shape, and extends a little beyond the extremity of

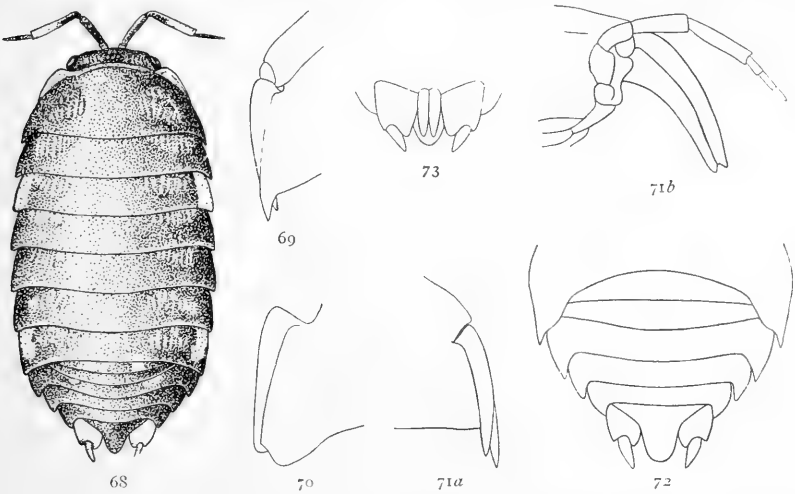


FIG. 68.—*Mesarmadillo quadricoloratus*, sp. nov. General figure. × 3 3/5.
FIG. 69.—*Mesarmadillo quadricoloratus*, sp. nov. Coxopodite of first thoracic segment (dorsal view). × $9\frac{1}{3}$.
FIG. 70.—*Mesarmadillo quadricoloratus*, sp. nov. Coxopodite of first thoracic segment (lateral view). × $9\frac{1}{3}$.
FIG. 71.—*Mesarmadillo quadricoloratus*, sp. nov. Coxopodite of first thoracic segment (ventral view). × $9\frac{1}{3}$.
FIG. 72.—*Mesarmadillo quadricoloratus*, sp. nov. Abdomen with uropoda. × $9\frac{1}{3}$.
FIG. 73.—*Mesarmadillo quadricoloratus*, sp. nov. Abdomen with uropoda (ventral view). × $9\frac{1}{3}$.

the apical process of the sixth abdominal segment. The inner branch extends almost to the tip of the sixth abdominal segment, but is not visible in a dorsal view. All the legs are ambulatory.

More than forty specimens were collected by Dr. O. F. Cook at Mt. Coffee; two specimens were collected by Mr. R. P. Currie, four by Mrs. Sharp, and two by Mr. Collins, in the same locality.

The type is in the possession of Dr. O. F. Cook

The co-type, collected at Mt. Coffee by Mr. R. P. Currie, is in the U. S. National Museum. Cat. no. 38,523.

This species is close to *Mesarmadillo quadrimaculatus* Budde-Lund,[1] but differs in color and the position of the four spots. The spots are described as being on the second and seventh thoracic segments in *M. quadrimaculatus,* while in the present species they are placed on the third and seventh segments. According to the figure of the uropoda and the sixth abdominal segment of *M. quadrimaculatus,*[2] the present species also differs in the length of the apical process of the sixth segment, being much shorter than that of *M. quadrimaculatus,* and in the shape and length of the basal article of the uropoda, which in *M. quadrimaculutus* is as long as the apical process of the sixth abdominal segment, is much longer than wide, and has the posterior margin truncate, while in the present species the basal article of the uropoda does not reach the apical process of the sixth abdominal segment, is not longer than wide, and has a deep excavation in the posterior margin, on either side of which the post-lateral angles are produced.

MESARMADILLO VARIEGATUS, sp. nov.

Body ovate, contractile into a ball. Surface smooth, punctate. Color, light and dark brown, mottled with yellow spots in no definite arrangement and in no constant relation, so that the body appears quite variegated.

Head much wider than long, 2½ mm. : 8 mm. Frontal margin straight and continuous with the epistome, which is flat. Front not margined. Eyes large, composite, situated at the lateral margins. First pair of antennæ small, inconspicuous. Second pair with the first article short; second article about twice as long as the first; third article about as long as the second; fourth article about one and a half times as long as the third; fifth article about one and a half times as long as the fourth. Flagellum composed of three nearly subequal articles.

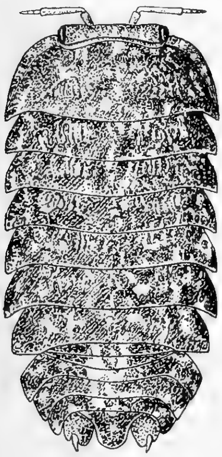
The first segment of the thorax is twice as long as any of those following, which are subequal. It is 6 mm. in length, and each of the following segments is 3 mm. long. The coxopodites of the first segment are wide, flat plates not much thickened, separated by a shallow groove from the segment, and not reaching to the post-lateral angles of the segments. They are cleft posteriorly, the inner portion being smaller than the exterior portion, and the

[1] A Revision of "Crustacea Isopoda Terrestria," pt. 1, Eubelum, 1899, pp. 14–15.

[2] *Ibid.,* Tab. III, fig. 15.

fissure not being very deep. The coxopodites of the second and third segments are present on the anterior margin of the segments as narrow thickened ridges.

The first two segments of the abdomen are covered laterally by the seventh thoracic segment. The third and fourth segments are slightly longer than the first, second, and fifth. The third and fourth segments are each $1\frac{1}{2}$ mm. in length. The first, second, and fifth segments are each about 1 mm. long. The lateral parts of the third, fourth, and fifth segments are well developed and are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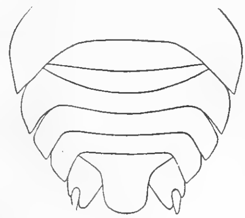
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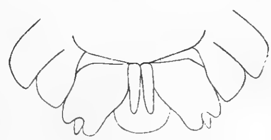
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FIG. 74.—*Mesarmadillo variegatus,* sp. nov. General figure. × 3 1/5.
FIG. 75.—*Mesarmadillo variegatus,* sp. nov. Coxopodite of first thoracic segment (dorsal view). × $9\frac{1}{3}$.
FIG. 76.—*Mesarmadillo variegatus,* sp. nov. Coxopodite of first thoracic segment (lateral view). × $9\frac{1}{3}$.
FIG. 77.—*Mesarmadillo variegatus,* sp. nov. Coxopodite of first thoracic segment (ventral view). × $9\frac{1}{3}$.
FIG. 78.—*Mesarmadillo variegatus,* sp. nov. Abdomen with uropoda. × $9\frac{1}{3}$.
FIG. 79.—*Mesarmadillo variegatus,* sp. nov. Abdomen with uropoda (ventral view). × $9\frac{1}{3}$.

directed backward. The sixth or terminal segment is triangular at the base and has the apex produced in a wide process, widely rounded at the extremity. The basal article of the uropoda is quadrangular in shape and occupies all the space between the lateral angles of the fifth abdominal segment and the produced apical portion of the sixth abdominal segment. It extends to the extremity of the terminal segment and to the tip of the lateral angles of the fifth segment. The posterior margin is deeply excavate about the middle, on either side of which the lateral angles are produced in rounded lobes, the inner one being the wider. The outer branch of the uropoda is large and extends a little beyond the lateral angles of the basal article. The inner branches are short, not reaching by some distance the extremity of the apical process of the sixth abdominal segment. All the legs are ambulatory.

About twenty specimens were collected by Dr. O. F. Cook at Mt. Coffee. One specimen was collected by Rev. George P. Goll and three by Mrs. Sharp in the same locality. Two specimens were collected by Mr. R. P. Currie in the same locality.

The type is in the possession of Dr. O. F. Cook.

The co-type, collected at Mt. Coffee by Rev. Geo. P. Goll, has been placed by Mr. R. P. Currie in the U. S. National Museum. Cat. no. 38,521.

Genus PERISCYPHOPS Budde-Lund

Periscyphops Budde-Lund, A Revision of "Crustacea Isopoda Terrestria," pt. 1, Eubelum, 1899, p. 15.

Flagellum of second antennæ composed of three articles. Coxopodites of first thoracic segment adjacent to and extending along the lateral margin of the segment, being separated from it by a longitudinal groove. The lateral margin of the coxopodite is not sulcate. The posterior margin is entire, the coxopodites not being cleft by any fissure separating them from the post-lateral angle of the segment, to which they are united. Coxopodites are present on the anterior portion of the underside of the second and third segments in the form of a narrow ridge.

Outer branch of uropoda inserted about the middle of the posterior margin of the basal article.

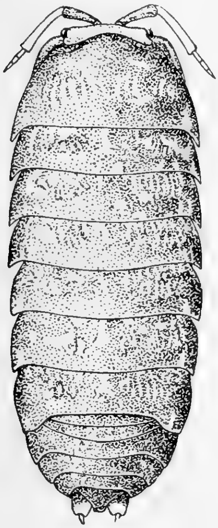
Analytical Key to the Species of the Genus PERISCYPHOPS from Liberia

a.—Terminal segment of abdomen with the apex produced in a short triangular process, with sides converging gradually to a rounded extremity, and not reaching the inner post-lateral angle of the basal article of the uropoda. Inner branches of the uropoda conspicuous in a dorsal view, and extending some distance beyond the extremity of the terminal abdominal segment and a little beyond the outer branch of the uropoda............................*Periscyphops brevicaudatus,* sp. nov.

a'.—Terminal segment of abdomen with the apex produced in a moderately wide process, with sides parallel and rounded at the extremity. Inner branches of the uropoda short, not conspicuous in a dorsal view and not reaching the extremity of the terminal abdominal segment.
Periscyphops cooki, sp. nov.

PERISCYPHOPS BREVICAUDATUS, sp. nov.

Body ovate, convex, contractile into a ball. Surface smooth, punctate, and with a small, pearliform granulation on each side of the thoracic segments. Color, dark brown, with a few light spots longitudinally arranged in the median band of dark brown and with wavy lines of light yellow on either side of the median line. The



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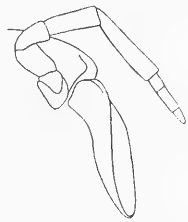

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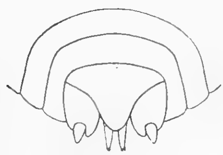

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FIG. 80.—*Periscyphops brevicaudatus,* sp. nov. General figure. × 3 1/5.
FIG. 81.—*Periscyphops brevicaudatus,* sp. nov. Coxopodite of first thoracic segment (dorsal view). × 7.
FIG. 82.—*Periscyphops brevicaudatus,* sp. nov. Coxopodite of first thoracic segment (lateral view). × 7.
FIG. 83.—*Periscyphops brevicaudatus,* sp. nov. Coxopodite of first thoracic segment (ventral view). × 7.
FIG. 84.—*Periscyphops brevicaudatus,* sp. nov. Last three segments of abdomen with uropoda. × 7.

pearliform granulations are yellow and also the fifth article of the peduncle and the flagellum of the antennæ.

Head wider than long, 3 mm. : 9 mm., with the front slightly produced in the middle, sinuate. Front not margined, but continuous with the epistome, which is produced in a slightly convex tubercle. Eyes small, composite, and situated at the lateral margins. The first pair of antennæ are small and inconspicuous. The second pair have the first article short; the second is nearly twice as long as the first; the third is as long as the second; the fourth is one and a half times longer than the third; the fifth is one and a half times longer than the fourth. The flagellum is composed of three articles, the second one being longer than either of the other two, which are about subequal.

The first segment of the thorax is longer than any of those following, which are subequal. The first segment is 6½ mm. in length. Each of the following six segments is 4 mm. long. The coxopodites of the first segment form a rather wide and very thickened marginal border on either side, separated from the segment by a deep furrow, wider anteriorly than posteriorly and not extending to the post-lateral angles of the segment. They are not cleft posteriorly and are not represented on the underside by any ridge or fold or thickness of the surface. The posterior margin is entire. The coxopodites of the second and third segments are present on the underside in the form of a slightly thickened ridge on the anterior margin of the segment.

The first two segments of the abdomen have the lateral parts covered by the seventh thoracic segment. The lateral parts of the following three segments are well developed and are produced backward. The third and fourth segments are slightly longer than the first, second, and fifth segments, which are subequal in length. The first, second, and fifth segments are each about 1½ mm. long. The second and third segments are each about 2 mm. in length. The sixth or terminal segment is triangular at the base, with the apex produced in a short triangular process, the sides converging gradually to a rounded extremity. The basal article of the uropoda is somewhat quadrangular in shape and occupies all the space between the lateral angles of the fifth segment and the produced apical process of the sixth segment. It extends a little beyond the lateral angles of the fifth segment and the apical process of the sixth segment. The posterior margin is excavate between the lateral angles, which are produced in lobes on either side. The inner lobe is slightly longer than the outer lobe. A carina extends longitudinally along the exterior margin of the basal article. The outer branch is rather large and extends half its length beyond the inner lateral angle of the basal article. The inner branch is long, extending beyond the apical process of the sixth abdominal segment and beyond the inner angle of the basal article, almost or quite to the extremity of the outer branch. All the legs are ambulatory.

Only one specimen was collected by Dr. O. F. Cook at Mt. Coffee. The type is in the possession of Dr. O. F. Cook.

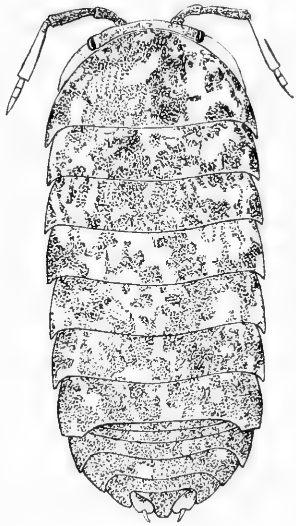
PERISCYPHOPS COOKI, sp. nov.

Body ovate, convex, contractile into a ball. Surface smooth, punctate, with a small pearliform granulation on each side of the thoracic segments. Color dark brown, mottled with yellow in irregular spots all over the body and in no definite arrangement. The flagellum and fifth article of the peduncle of the antennæ and the coxopodites of the first thoracic segment are yellow.

The head is wider than long, 3 mm. : 9 mm., with the frontal margin produced in the middle, sinuate. The front is not margined, but is continuous with the epistome, which is produced in a rounded convexity. The eyes are small, composite, and situated at the lateral margins. The first pair of antennæ are small and inconspicuous. The second pair have the first article short; the second article is twice as long as the first; the third is about equal in length to the second; the fourth is one and a half times longer than the third; the fifth is a little longer than the fourth. The flagellum is composed of three articles, the second of which is longer than either of the other two, which are subequal.

The first segment of the thorax is about twice as long as any of the following, which are subequal. The first segment is 7 mm. in length. Each of the following segments is 3½ mm. long. The coxopodites of the first segment form a rather wide marginal border on either side, wider anteriorly than posteriorly, very much thickened and separated from the segment by a deep groove. They disappear posteriorly and do not reach the post-lateral angles of the segment by some distance. The posterior portion is entire, and not cleft. The coxopodites are not represented on the underside of the segment by any thickness of the margin or any ridge. The coxopodites of the second and third segments are present on the anterior portion in the form of a thickened ridge on the underside.

The first two segments of the abdomen are covered laterally by the seventh thoracic segment. The lateral parts of the following three segments are well developed and are produced backward. The third and fourth segments are longer than either the first, second, or fifth segments, which are subequal. The sixth or terminal segment is triangular at the base and has the apex produced in a moderately wide process, with sides parallel and rounded at the apex. The basal article of the uropoda is quadrangular in shape and occupies all the space between the lateral angles of the fifth segment and the apical process of the sixth segment. It reaches the extremity of the lateral angles of the fifth segment, but does not extend to the tip of the sixth segment. There is a slight carina, longitudinally placed near the outer margin. The posterior margin is excavate between the produced lateral angles. The outer branch is large and extends to the tip of the apical process of the sixth segment. The inner branch does not quite reach the extremity of the sixth segment. All the legs are ambulatory.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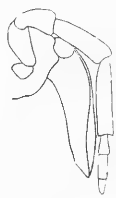
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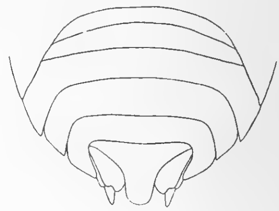
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FIG. 85.—*Persicyphops cooki,* sp. nov. General figure. × 4.
FIG. 86.—*Periscyphops cooki,* sp. nov. Coxopodite of first thoracic segment (lateral view). × 7.
FIG. 87.—*Periscyphops cooki,* sp. nov. Coxopodite of first thoracic segment (ventral view). × 7.
FIG. 88.—*Periscyphops cooki,* sp. nov. Abdomen with uropoda (dorsal view). × 7.
FIG. 89.—*Periscyphops cooki,* sp. nov. Abdomen with uropoda (ventral view). × 7.

Twelve specimens of this species were collected by Dr. O. F. Cook at Mt. Coffee and at Monrovia. One specimen was collected by Mrs. Sharp at Mt. Coffee. The type is in the possession of Dr. O. F. Cook.

This species closely resembles *Periscyphops alluaudi* (Dollfus),[1] but differs in the much shorter apical process of the sixth abdominal segment, in the shorter basal article of the uropoda *per se,* and also

[1] Ann. Soc. Entomologique France, LXI, 1892, pp. 386–387, pl. 7, figs. 1*a*. 1*b*, 1*c*.

in its relation to the apical process of the sixth segment and in the coloration, *P. alluaudi* being almost uniformly brownish gray, with the borders of the segments red, while the present species is brown, mottled with numerous yellow spots.

Genus ETHELUM Budde-Lund

Ethelum BUDDE-LUND, A Revision of "Crustacea Isopoda Terrestria," pt. 1, Eubelum, 1899, p. 24.

Flagellum of second antennæ composed of two articles. Coxopodites of first thoracic segment adjacent to and extending along the lateral margin of the segment, being separated from it on either side by a longitudinal groove. The lateral margin of the coxopodite is not sulcate. The coxopodites are cleft posteriorly, a fissure separating them from the post-lateral angle of the segment.

Epimera are present on the anterior portion of the underside of the second and third segments in the form of a narrow ridge.

The outer branch of the uropoda is usually inserted about the middle of the posterior margin of the basal article.

ANALYTICAL KEY TO THE SPECIES OF THE GENUS ETHELUM FROM LIBERIA

a.—Apical process of sixth abdominal segment with extremity rounded.
- *b.*—Outer branch of the uropoda minute, inserted in a shallow notch at the inner post-lateral angle of the basal article. Without yellow spots on either side of the second and seventh thoracic segments.
Ethelum rotundatum, sp. nov.
- *b′.*—Outer branch of the uropoda not minute, large, inserted in a deep notch in the middle of the posterior margin of the basal article. With a conspicuous yellow spot on either side of the second and seventh thoracic segments.......*Ethelum quadrimaculatum,* sp. nov.

a′.—Apical process of sixth abdominal segment not rounded at the extremity.
- *b.*—Apical process of sixth abdominal segment attenuated, in the form of a long, narrow process. Coxopodites of first thoracic segment shorter than the post-lateral angles. Fifth article of peduncle of second antennæ one and a half times as long as the fourth article.
Ethelum attenuatum, sp. nov.
- *b′.*—Apical process of sixth abdominal segment wide, with extremity truncate. Coxopodites of first thoracic segment longer than the post-lateral angles of the segment. Fifth article of peduncle of second antennæ but little longer than the fourth article.
Ethelum liberiensis, sp. nov.

ETHELUM ROTUNDATUM, sp. nov.

Body ovate, convex, contractile into a ball. Surface smooth, punctate. Color, dark brown, with indistinct wavy lines of light brown on either side of the median stripe of dark brown. There is a minute granule on either side of each one of the thoracic segments.

Head wider than long, 3 mm. : 7 mm., with the frontal margin straight. Front not margined but continuous with the epistome, which is flat. Eyes small, composite, and situated at the lateral margins. First pair of antennæ small and inconspicuous. Second pair of antennæ with the first article small; the second article is

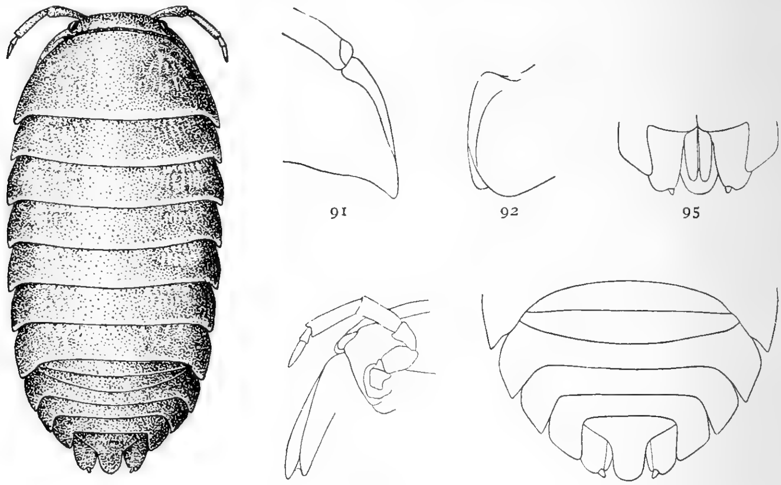

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FIG. 90.—*Ethelum rotundatum*, sp. nov. General figure. × 4.
FIG. 91.—*Ethelum rotundatum*, sp. nov. Coxopodite of first thoracic segment (dorsal view). × $9\frac{1}{3}$.
FIG. 92.—*Ethelum rotundatum*, sp. nov. Coxopodite of first thoracic segment (lateral view). × $9\frac{1}{3}$.
FIG. 93.—*Ethelum rotundatum*, sp. nov. Coxopodite of first thoracic segment (ventral view). × $9\frac{1}{3}$.
FIG. 94.—*Ethelum rotundatum*, sp. nov. Abdomen with uropoda (dorsal view). × $9\frac{1}{3}$.
FIG. 95.—*Ethelum rotundatum*, sp. nov. Abdomen with uropoda (ventral view). × $9\frac{1}{3}$.

about one and a half times longer than the first; the third is about as long as the second; the fourth is a little longer than the third; the fifth is about one and a half times longer than the fourth. The flagellum is composed of two articles, the second of which is about twice as long as the first.

The first segment of the thorax is twice as long as any of those following, which are subequal. The first segment is 6 mm. in length. Each of the following six segments is 3 mm. long. The coxopodites of the first segment form a narrow border on either side, wider anteriorly than posteriorly and considerably thickened. They are separated from the segment by a rather deep groove, and do not quite reach the post-lateral angles of the segment. They are cleft posteriorly, the fissure not being very deep, and the inner portion is smaller than the outer. The coxopodites are present on the anterior portion of the second and third segments in the form of thickened ridges, that of the second segment being more in the form of a tooth with sharp edge.

The first two segments of the abdomen have the lateral parts covered by the seventh thoracic segment. The lateral parts of the following three segments are well developed and produced backward. The first five segments are about equal in length. The sixth or terminal segment has the base triangular in shape, with the apex produced in a moderately wide process, with parallel sides and rounded at the extremity. The basal article of the uropoda is quadrangular in shape and occupies all the space between the lateral angles of the fifth segment and the apical process of the sixth segment. It extends to the end of the lateral angles of the fifth segment and to the tip of the apical process of the sixth segment. A longitudinal carina extends along the entire length of the article near the inner margin. There is a shallow notch or excavation in the posterior margin near the inner angle, in which the small outer branch is inserted. The inner branch does not reach by some distance the extremity of the apical process of the sixth abdominal segment. The legs are all ambulatory.

One specimen of this species was collected by Dr. O. F. Cook at Mt. Coffee, and four others were collected at Sierra Leone.

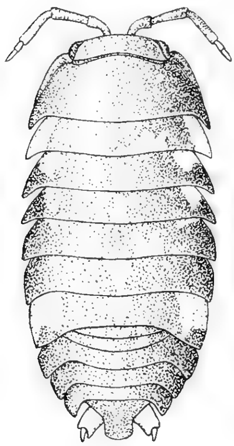
The type is from Sierra Leone and is now in the possession of Dr. O. F. Cook.

All the species of this genus hitheto described are from the West Indies.

ETHELUM QUADRIMACULATUM, sp. nov.

Body ovate, slightly convex, contractile into a ball. Surface smooth. Color, brown, mottled with yellow, there being four large conspicuous yellow spots, one on either side of the second thoracic segment and one on either side of the seventh thoracic segment, occupying the entire lateral part of the segment. The uropoda are also yellow, as well as the two basal articles of the peduncle of the second antennæ. There is a minute granule on either side of each one of the thoracic segments.

The head is wider than long, 1½ mm. : 4 mm., with the front straight and not margined. Epistome flat. Eyes small, round, composite, situated at the lateral margins. The first pair of antennæ are rudimentary and nearly inconspicuous. The second pair have the first article short; the second article is about two and a half times as long as the first; the third article is as long as the second; the fourth is about one and a half times as long as the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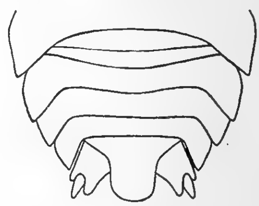
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FIG. 96.—*Ethelum quadrimaculatum,* sp. nov. General figure. × 5.
FIG. 97.—*Ethelum quadrimaculatum,* sp. nov. Coxopodite of first thoracic segment (dorsal view). × 14.
FIG. 98.—*Ethelum quadrimaculatum,* sp. nov. Coxopodite of first thoracic segment (lateral view). × 14.
FIG. 99.—*Ethelum quadrimaculatum,* sp. nov. Coxopodite of first thoracic segment (ventral view). × 14.
FIG. 100.—*Ethelum quadrimaculatum,* sp. nov. Abdomen with uropoda (dorsal view). × 14.
FIG. 101.—*Ethelum quadrimaculatum,* sp. nov. Abdomen with uropoda (ventral view). × 14.

third; the fifth is a little longer than the fourth. The flagellum is composed of two articles, the second one of which is about three times as long as the first.

The first segment of the thorax is nearly twice as long as any of those following, which are subequal. The first segment is 2½ mm. long; each of the following is 1½ mm. in length. The coxopodites of the first thoracic segment are wide plates, extending along the lateral margin, but not reaching by a small distance the post-lateral angles of the segment. They are separated by a deep furrow from the segment and are cleft posteriorly, the fissure not being deep, and the inner portion separated smaller than the outer. Coxopodites are present on the anterior portion of the second and third thoracic segments on the underside in the form of thickened ridges, thicker on the second than on the third segment.

The first two segments of the abdomen have the lateral parts covered by the seventh thoracic segment. The lateral parts of the three following segments are well developed and are directed backward. The first, second, and fifth segments are subequal and are somewhat shorter than either the third or fourth, which are also subequal. The sixth or terminal segment is triangular at the base, with the apex produced in a rather wide process, with sides parallel and extremity rounded. The basal article of the uropoda is quadrangular in shape and occupies all the space between the lateral parts of the fifth abdominal segment and the apical process of the sixth segment. It extends to the extremity of the lateral angles of the fifth segment as well as to the tip of the apical process. The posterior margin has a deep notch about the middle, on either side of which the lateral angles are produced in rounded lobes, the inner one being the longer. The outer branch of the uropoda is large and conical in shape, and extends for about half its length beyond the inner lateral angle of the basal article. The inner branch extends to the extremity of the apical process of the terminal abdominal segment. All the legs are ambulatory.

Three specimens of this species were collected in Liberia—one at Mt. Coffee by Dr. O. F. Cook, another at Mt. Coffee by Mr. Collins, and another by Dr. O. F. Cook from a locality not named.

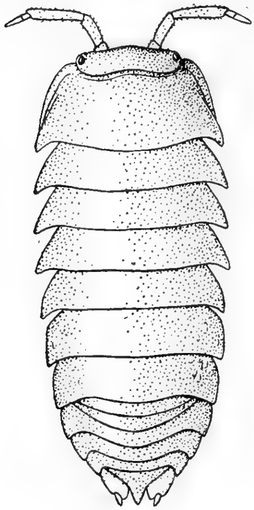
The type is in the possession of Dr. O. F. Cook.

This species resembles superficially *Mesarmadillo quadrimaculatus* in the color markings, having the four large yellow spots, as in that species, one on either side of the second thoracic segment and one on either side of the seventh thoracic segment. This species, however, belongs unmistakably to the genus *Ethelum*, having but two articles to the flagellum of the second antennæ. *Mesarmadillo quadricoloratus* also has four large yellow spots, but they are placed one on either side of the third thoracic segment and one on either side of the seventh thoracic segment.

ETHELUM ATTENUATUM, sp. nov.

Body ovate, convex, contractile into a ball. Surface smooth, punctate. Color, yellow, mottled with brown on the posterior half of the body.

Head wider than long, 2 mm. : 5 mm., with the frontal margin straight and continuous with the epistome, which is flat. Eyes small, composite, and situated at the lateral margins. The first pair of antennæ are small and inconspicuous. The second pair have the first article short; the second is twice as long as the first; the third is about as long as the second; the fourth is one and a half times longer than the third; the fifth is a little longer than the



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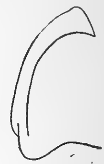

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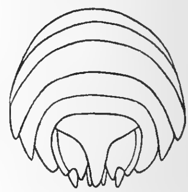

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FIG. 102.—*Ethelum attenuatum*, sp. nov. General figure. × 7 1/5.

FIG. 103.—*Ethelum attenuatum*, sp. nov. Coxopodite of first thoracic segment (lateral view). × 14.

FIG. 104.—*Ethelum attenuatum*, sp. nov. Coxopodite of first thoracic segment (ventral view). × 14.

FIG. 105.—*Ethelum attenuatum*, sp. nov. Abdomen with uropoda (dorsal view). × 14.

fourth. The flagellum is composed of two articles, the second one of which is two and a half times longer than the first.

The first segment of the thorax is about twice as long as any of those following, which are subequal. The first segment is 3 mm. in length. Each of the six following segments is about 1½ mm. long. The coxopodites of the first segment form a rather wide and thickened border on each side, somewhat wider anteriorly than posteriorly, and separated from the segment by a very deep furrow. They do not reach by some distance the post-lateral angles of the segment, and are cleft posteriorly, the fissure not being very deep and the inner portion smaller than the outer portion. The coxopodites of the second and third segments are present on the anterior portion of the underside in the form of a sharp ridge, more prominent and thicker on the second segment.

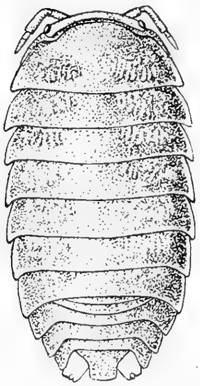
The first two segments of the abdomen have the lateral parts covered by the seventh thoracic segment. The lateral parts of the three following segments are well developed and directed backward. The third and fourth segments are a little longer than the first, second, and fifth segments, which are subequal. The sixth or terminal segment is triangular at the base, with the apex produced in a long triangular process, the sides of which converge gradually to a rather acute extremity. The basal article of the uropoda is quadrangular in shape, and occupies all the space between the lateral angles of the fifth segment and the apical process of the sixth segment. It extends to the extremity of the lateral angles of the fifth segment, but not to the extremity of the apical process of the sixth segment by some little distance. The posterior margin is excavate between the produced lateral angles, the inner angle being a little narrower and more acute than the outer one. The outer branch of the uropoda is large, conical, and extends a little beyond the apical process of the sixth abdominal segment. The inner branch just reaches the tip of the apical process. All the legs are ambulatory.

Only one specimen was collected by Dr. O. F. Cook at Mt. Coffee. The type is in the possession of Dr. O. F. Cook.

ETHELUM LIBERIENSIS, sp. nov.

Body very convex, contractile into a ball. Surface smooth, with a tiny pearl-like granulation on either side of the second, third, sixth, and seventh thoracic segments and the third abdominal segment. Color, grayish brown, with wavy lines of yellow on either side of the median longitudinal stripe, and with a large yellow spot on either side of the second thoracic segment at the lateral margins. Uropoda yellow, as well as the first three articles of the peduncle of the second antennæ. Head wider than long, with the front straight and not margined, but continuous with the epistome, which is produced in a convex tubercle. The eyes are small, composite, and situated at the lateral margins. The first pair of antennæ are rudimentary and inconspicuous. The second pair have the first article short; the second is twice as long as the first; the third is as long as the second; the fourth is equal in length to the third; the fifth is but little longer than the fourth. The flagellum is composed of two articles, the second of which is more than twice as long as the first.

The first segment of the thorax is about twice as long as any of those following, which are subequal in length. The coxopodites are adjacent to and extend along the lateral margin of the segment, being separated by a longtitudinal groove. They extend beyond the post-lateral angles of the segment and are separated from them posteriorly by a fissure, the inner portion cleft being larger than the outer portion. Coxopodites are present on the anterior portion of the underside of the second and third thoracic segments in the form of a sharp tooth.



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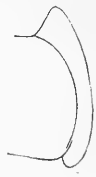

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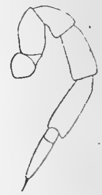

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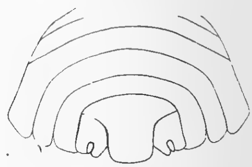

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FIG. 106.—*Ethelum liberiensis,* sp. nov. General figure.

FIG. 107.—*Ethelum liberiensis,* sp. nov. Coxopodite of first thoracic segment (lateral view). × 29.

FIG. 108.—*Ethelum liberiensis,* sp. nov. Coxopodite of first thoracic segment (ventral view). × 29.

FIG. 109.—*Ethelum liberiensis,* sp. nov. Second antenna. × 29.

FIG. 110.—*Ethelum liberiensis,* sp. nov. Abdomen with uropoda (dorsal view). × 21¾.

FIG. 111.—*Ethelum liberiensis,* sp. nov. Abdomen with uropoda (ventral view). × 21¾.

The first two segments of the abdomen have the lateral parts covered by the seventh thoracic segment. The lateral parts of the three following segments are well developed and produced backward. The first, second, and fifth segments are subequal in length, and each is a little shorter than either the third or fourth segments, which are also subequal. The sixth or terminal segment is triangular at the base and has the apex produced in a broad process, with parallel sides and extremity truncate, the post-lateral angles being rounded. The basal article of the uropoda is quadrangular and occupies all the space between the lateral angles of the fifth segment and the apical process of the sixth segment. It extends to the extremity of the lateral angles of the fifth segment as well as to the extremity of the apical process of the sixth segment. There is a deep notch about the middle of the posterior margin, on either side of which the lateral angles are produced in the form of lobes. The outer branch is inserted in the median posterior notch of the basal article and does not extend beyond the lateral angles. The inner branch does not reach by some distance the extremity of the apical process of the sixth abdominal segment. All the legs are ambulatory.

Only one specimen of this species was collected by Dr. O. F. Cook at Mt. Coffee. The type is in the possession of Dr. O. F. Cook.

Genus ETHELUMORIS, gen. nov.

Second pair of antennæ short. Flagellum composed of two articles.

First segment of thorax with the epimera or coxopodites arising from the underside and extending in the form of wide plates along the entire lateral margin. They are produced beyond the post-lateral angles of the segment and are cleft posteriorly by a deep fissure, which separates the large inner portion from the smaller outer portion. Second and third thoracic segments produced laterally in a small, triangular lobe on either side, beneath which on the underside the coxopodites are present in the form of a sharp tooth on the second segment and a low ridge on the third segment.

The sixth or terminal segment is triangular at the base, with the apex produced in a triangular process, with sides converging gradually to a rounded extremity. The basal article of the uropoda is quadrangular in shape, with the posterior margin excavated in the middle, in which the outer branch is inserted. The outer post-lateral lobe extends back of the outer branch. The inner branch of the uropoda is not visible on the ventral side, but is hidden by the apical process of the sixth abdominal segment. This branch arises from the inner upper angle of the basal article and is conically produced.

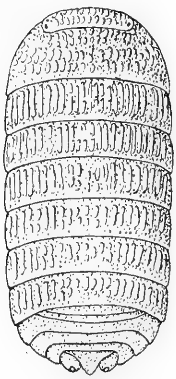
In the form of the coxopodites of the first thoracic segment, this genus approaches *Sphærarmadillo* Richardson, but differs in the form and position of the uropoda.

The type is *Ethelumoris parallelus*.

ETHELUMORIS PARALLELUS, sp. nov.

Body ovate, extremely convex, contractile into a ball. Surface, with the exception of the abdomen, which is smooth, covered with rugosities, rounded on the head in the form of low tubercles and elongated on the thoracic segments in the form of parallel ridges. Color, light brown, with wavy lines of yellow on either side of the median stripe.

Head is wider than long, 2 mm. : 4½ mm., with the front straight and margined. Epistome with a shield-like convexity. First pair



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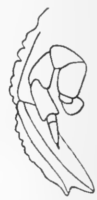

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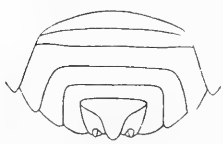

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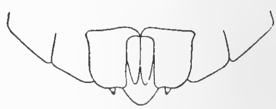

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FIG. 112.—*Ethelumoris parallelus,* sp. nov. General figure. × 7½.

FIG. 113.—*Ethelumoris parallelus,* sp. nov. Coxopodite of first thoracic segment and lateral part of second segment (lateral view). × 14.

FIG. 114.—*Ethelumoris parallelus,* sp. nov. Coxopodite of first thoracic segment (ventral view). × 14.

FIG. 115.—*Ethelumoris parallelus,* sp. nov. Abdomen with uropoda (dorsal view). × 14.

FIG. 116.—*Ethelumoris parallelus,* sp. nov. Abdomen with uropoda (ventral side). × 29.

of antennæ small and inconspicuous. Second pair with the first article short; the second article is twice as long as the first; the third is as long as the second; the fourth is equal in length to the third; the fifth is also short and not perceptibly longer than the fourth. The flagellum is composed of two articles, the second of which is about twice as long as the first.

The first segment of the thorax is about twice as long as any of the following segments, which are subequal. The first segment is about 3 mm. long. Each of the following segments is 1½ mm. in length. The coxopodites of the first segment are placed on the underside and extend along the entire length of the lateral margin in the form of wide plates, narrower anteriorly than posteriorly. They extend considerably beyond the post-lateral angles of the segment and are rounded posteriorly. A deep fissure separates them posteriorly from the post-lateral angles of the segment, the inner portion being much larger than the outer portion. The lateral margins of the second and third segments are drawn out on either side in a small, triangular lobe, on the underside of which the coxopodite appears in the form of a sharp tooth on the second segment and in the form of a low ridge on the third segment.

The first two segments of the abdomen are covered laterally by the seventh thoracic segment. The lateral parts of the three following segments are well developed and are produced backward. The first five segments are subequal in length. The sixth or terminal segment is triangular at the base, with the apex produced in a triangular process, with sides converging gradually to a rounded extremity. The basal article of the uropoda is quadrangular and occupies all the space between the produced lateral parts of the fifth abdominal segment and the apical process of the sixth segment. It extends to the extremity of the lateral parts of the fifth segment, but not quite to the apex of the sixth segment. There is a deep excavation in the middle of the posterior margin, in which the outer branch is placed, and the outer post-lateral angle of the basal article extends back of the branch. The outer branch extends but little beyond the post-lateral angles of the basal article. The inner branch does not reach the extremity of the terminal abdominal segment, but attains the tip of the inner post-lateral angle of the basal article of the uropoda. All the legs are ambulatory.

Only one specimen was collected by Dr. O. F. Cook at Mt. Coffee. The type is in the possession of Dr. O. F. Cook.

THE RELATIONS OF THE CHINESE TO THE PHILIPPINE ISLANDS

By BERTHOLD LAUFER

The history of the Spaniards on the Philippines is an endless chain of frictions and struggles with the Chinese immigrants and settlers, so that the history of the Philippines during the last three centuries is very closely interwoven with an account of the relations between these two peoples. The trade with China was by far the most important business of the Spanish colony—and with it the fortunes of the colony rose and fell. An abundant mass of material has been stored up by Spanish writers since this early contact with the East, from which the political and commercial history of Chinese intercourse might well be compiled; but no attempt has heretofore been made to call to witness coeval Chinese sources, and to compare Spanish accounts with Chinese testimony on the same subject. To advance a step in this direction and do justice to the *audiatur et altera pars* is the prime object of the present paper.

The Chinese have been acute observers of foreign nations and countries, and in their astoundingly vast amount of literature we find many valuable reports on the geography, history, and ethnology of the neighboring peoples. The history of the Malayan Archipelago (particularly, for example, Java and Sumatra) during the pre-colonial age would be almost shrouded in mystery but for the material regarding these islands hoarded up by the Chinese.[1] The principal Chinese sources of which I have made use are the Annals of the Ming dynasty, or the "Ming shih," which, in chapter 323, furnishes an account of all islands in the eastern Pacific known to the Chinese at that time, and also of the Portuguese, Spanish, and Dutch, who then made their first appearance in the Far East. Furthermore, the annals of the provinces of Kuang-tung and Fuh-kien frequently speak of the Philippines, and describe historical and other incidents relating to them, for the natural reason that the traders and seafaring people of those parts of China were most

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[1] The principal papers on this subject are: L. de Rosny, Les peuples orientaux connus des anciens Chinois (Paris, 1881); W. T. Groeneveldt, Notes on the Malay Archipelago and Malacca, compiled from Chinese sources (Batavia, 1876), and Supplementary Jottings to this paper in *T'oung Pao* (1896), vol. VII, pp. 113-134. Groeneveldt has not dealt with the Philippines.

active in transmarine undertakings. The geographical literature of the Chinese also abounds in accounts of the Philippines. The most important of these, frequently alluded to in these pages, is the "Tung hsi yang k'ao" ("Investigations regarding the Eastern and Western Ocean"), published in 1618—a very useful geographical work in twelve books, the descriptions of which, as a rule, refer to the time when Europeans first began to visit the Malayan regions.[1]

The appearance of the Spaniards in Eastern waters was not the first occasion on which the Chinese had taken cognizance of these Western people. From the accounts of the Arabs, they had gained a certain knowledge of Spain as early as the beginning of the thirteenth century. Chao Ju-kua, a member of the imperial family of the Sung dynasty (960-1278) and superintendent and commissioner of customs in Ts'üan-chou-fu, a coast town northward from Amoy, in Fuhkien Province, came in close touch with merchants from India, Persia, Syria, and Arabia, who traded in that port with the Chinese, and availed himself of this opportunity to collect valuable data regarding the countries and peoples of the West. In his book, "Chu fan chi," written between 1209 and 1214, a brief description is given of Spain under the name *Mu-lan-p'i; i. e.*, the Arabian word *Murâbit,* which we find hispanicized as the dynasty of the *Almoravides.* He relates that Spain entertained a lively commerce with the *Ta-shih* (Arabs), and emphasizes the large size of her ships, which could carry several thousand men. Wheat, melons, pomegranates, lemons, rice, and salads are mentioned as the products of the country, and it is curious to find merino sheep mentioned as being several feet high and having tails the size of a fan.[2]

In the "Ming shih" and according to later sources, the name for Spain is *Yü-ssŭ-la* (or *Yü-mi-la,* by confounding the similar characters for *mi* and *ssŭ*), apparently an imitation of the sounds in the name *las Islas,* which the Chinese had heard from the Spaniards on the Philippines. The ordinary designation for Spain and Portugal, however, is simply *Hsi yang* (*i. e.*, "Western Ocean"), with the distinction that Spain is called *Hsiao hsi yang* ("the small Western Ocean"), and Portugal *Ta hsi yang* ("the great Western Ocean"), as the Portuguese were the first of the two to come under the notice of the Chinese. At a later period these names, *Hsi yang* and *Ta hsi yang,* were used in a general way for Europe, the name of which,

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[1]See A. Wylie, Notes on Chinese Literature, 2d edition, p. 58; Groeneveldt, Notes on the Malay Archipelago, p. VIII.

[2] F. Hirth, Die Länder des Islâm nach chinesischen Quellen (Leiden, 1894), pp. 48-50, 63.

toward the close of the fifteenth century, became known in China also in the transcription *Ou-lo-pa.* In the Portuguese-Chinese vocabulary appended to the "Ao men chi lio," the Chinese chronicle of Macao, we find that the Portuguese name for Ta hsi yang (Portugal) is *Lien-nu,* by which is evidently understood *Lusitania;* while the Portuguese name for Spain is written *Wo-ya,* reading in the Amoy dialect *Nga-ñia* (that is, in Portuguese apparently *Hespanha*). These designations, however, were those of geographical and diplomatic language; the popular term by which the Portuguese and Spanish were both spoken of, and even confounded with each other in literature, was *Fo-lang-ghi; i. e.,* "the Franks."

The main island of the Philippine group, Luzon, was known to the Chinese, long before the Spanish Conquest, under its native name *Luzong,* which appears in the texts in the form *Lü-sung.* This name was also extended to the entire group of islands, and, furthermore, was applied as a tribal name to the native population. At the time when the Spaniards took possession of the Philippines the name Lü-sung designated principally the city of Manila, but it was then transferred also to the Spaniards, who are the "Luzon men" of the Chinese annals, or, officially, *Ta Lü-sung kuo.* At that time a nickname was also invented for the Spaniards in the form *Sung-tsai,* which may be explained as follows: The character "sung" in Lü-sung is identical with that in the name of the Sung dynasty of China, which, like all dynasties, has the adjective *ta* ("great") prefixed to its title. In contrast to the great Sung dynasty, the foreign Lü-sung men were contemptuously called *Sung-tsai; i. e.,* the little Sung. A still more derogatory term under which the Spaniards go in the "Ming shih," in passages of a kind to provoke the criticism of the author, is *Man* (*i. e.,* savages), originally a name restricted to the primitive aboriginal tribes of southern China.

In modern times the Portuguese retained their old historical name, *Ta hsi yang kuo,* in diplomatic intercourse with the Chinese court, while the Spaniards adopted the transliteration *Ta Jih-ssŭ-pa-*(or *pan*)*-ni-yakuo,* which has come up since the early days of the Jesuits; also Lü-sung is still the Chinese name for Manila, Luzon, and the Philippines generally, and *Lü-sung yen* ("Luzon smoke") is a common term for Manila cigars. In connection with this terminology it might not be without interest to add that the name "America" occurs for the first time in Chinese literature (about a century after its discovery) in the "Ming shih" (chap. 326) as "*A-mo-le-kia,*" in connection with a report on the famous Jesuit

Matteo Ricci, who presented to the Emperor a map of the world on which he stated that "there are in the world five parts of the globe. The fourth of these was America."[1]

It is at a comparatively late date that Chinese history makes mention of the Philippine Islands; and this fact is the more striking, since some of the adjacent isles to the south are touched upon much earlier. The Moluccas, for example, are first mentioned, under the name *Mi-li-kü,* in the Annals of the T'ang dynasty (618-906), in determining the site of the island of Bali, although no special description of them is given earlier than the sixteenth century.[2] Puni—that is, Brunei, or the northwest coast of Borneo—appears in the history of the Sung dynasty (960-1279),[3] and we cannot but think that navigators sailing there must have passed the great island of Palawan or some isles of the Sulu Archipelago. However this may be, the Philippines are not actually mentioned by name in literature earlier than the time of the Ming dynasty (*Ming shih,* chap. 323, p. 11 a). In the fifth year of the period Hung-wu (1372) the first embassy from the Philippines arrived in China with tribute. The site of Luzon is stated on this occasion to be in the South Sea very close to Chang-chou in Fuhkien. The Emperor reciprocated the gifts of this embassy by despatching an official with presents of silk gauze woven of gold and colored threads to the king of the country. From this first mention of the Philippines in Chinese history we should not be so narrow-minded as to infer that Chinese intercourse with the Philippines dates from just the year 1372; on the contrary, the fact that there was a Philippine embassy in that year points to a long commercial intercourse between the two peoples, which had escaped the knowledge of the court historiographers at Peking. Although the imperial geography of the Ming, the "Ta Ming i t'ung chi," states expressly that no investigation of Luzon had been made by earlier generations, this is refuted by the fact that we meet with an account of the Philippine tribes in the before-mentioned "Chu fan chi" of Chao Ju-kua in the thirteenth century.[4] Chao Ju-kua describes a country in the north of Borneo which he calls *Ma-yi(t)*, which name Professor Blumentritt thinks is identical with Bay, the

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[1] E. Bretschneider, Mediæval Researches from Eastern Asiatic Sources, vol. II (London, 1888), p. 324.

[2] Groeneveldt, loc. cit., p. 117.

[3] Ibid., pp. 106, 108.

[4] The passage in question has been translated by Professor Hirth in his book "Chinesische Studien," p. 40.

territory of Manila;[1] and speaks further of a country called *San hsü*[2] ("The Three Islands"—Ka-ma-yen, Pa-lao-yu, and Pa-ki-nung). The sketch of the native population given by him is very interesting. He says:

> On each island lives a different tribe. Each tribe consists of about a thousand families. As soon as a foreign ship comes in sight, the natives approach it to barter. They live in rush huts. As there are no springs in the mountains, the women carry two or three jugs at the same time on their heads, in which they fetch water from the springs in the plain, and with this load they ascend the mountains as easily as if they were walking on level ground. In the most hidden valleys live people called *Hai-tan* (the Aëta or Negritos). They are of small stature, have round brown eyes and frizzled hair, and their teeth shine between their lips. They live high up in the tops of trees,[3] where they dwell in families of from three to five individuals. Crawling through the thickets of the forests, they shoot from ambush at passers-by; wherefore they are much dreaded; but if a porcelain cup is thrown towards them they rush on it, shouting with joy, and escape with their spoil.

Then the mode of trading with the merchants of the Chinese ships is related. The native articles traded were cotton, cotton goods, beeswax, cocoanut, and fine mats, while the Chinese exchanged for them silk parasols, porcelain, and baskets plaited of rattan. Even in 1572 the inhabitants of Cagayan told the captain Juan de Salcedo, that their cotton weavings were bought up yearly by Chinese and Japanese traders. Chinese-Philippine trade must therefore have existed early in the thirteenth, and very likely in the latter part of the twelfth century.

Perhaps a still earlier ethnographical allusion to a Philippine tribe

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[1] I am rather inclined to believe that the island of Mindoro is meant, which, according to Blumentritt (Versuch einer Ethnographie der Philippinen, p. 65), was called *Mait* in oldest times. In all likelihood the Chinese were acquainted with Mindoro at an earlier date than with Luzon. It was on Mindoro that in 1571 Spaniards and Chinese met for the first time. The Three Islands are probably Busuanga, Calamian, and Peñon de Coran. Of other localities mentioned by Chao Ju-Kua, Pai-pu-yen may be identified with the Babuyan north of Luzon; Pu-li-lu with Polillo, eastward from Luzon.

[2] An island group of the same name is mentioned in the History of the Mongol Dynasty as situated near Formosa, with a population of only 200 families. In language these people seem to have been different from the Formosans, for the latter could not understand the speech of an interpreter from there in the service of the Chinese. The group is certainly not the same as that above (see *Yüan shih,* chap. 210, pp. 4-5).

[3] The *Tung hsi yang k'ao* mentions a mountain range on Luzon by the name of *Fou-ting-shan.* It says: "Wild barbarians dwell in nests on the top of these mountains, and shoot from trees at birds and animals, which they eat uncooked. One cannot follow their trails."

is contained in the "History of the Sung Dynasty" (*Sung shih*), in the chapter giving the history of Formosa for that period. After a few remarks on the native tribes of the island, the report goes on to say:

Near them (*i. e.,* the Formosans) is the land of the Pi-sia-ye (Visaya), whose language is not understood [on Formosa]. They go naked, and from the way they stare, one would say they are not like other people. In the period Shun-hsi (A. D. 1174-1189) the chief of that country daringly took some hundreds of his men and suddenly appeared in the Bay of Ts'üan-chou (Fuhkien Province). In Wei-t'ou and other villages they committed outrages and murder. In their plundering they looked chiefly for iron implements, spoons, and chop-sticks. When people shut their doors, they desisted, and only cut off the rings of the door-knockers. When spoons and chop-sticks were thrown to them, they stooped to gather them. When they saw a rider clad in iron, they struggled among themselves to cut off his armor; then, joining forces, slew him mercilessly. In close combat they availed themselves of spears, to which a rope of more than a hundred feet in length was attached with which to handle the weapon, for they save their iron and do not recklessly throw it aside. They had no boats or oars, but rafts made of bamboo poles tied together. Hurriedly they carried these off jointly, set them afloat, and disappeared.

The identification of the Pi-sia-ye mentioned in this text with the Visaya of the Philippines has already been proposed by Terrien de Lacouperie,[1] but has been rejected by G. Schlegel[2] on the ground that it is impossible that those islanders should have been able to make the long passage over sea on rafts, as the Chinese historian says—a feat which, however, was possible from Formosa to Fuhkien. Schlegel accordingly seems to infer, but does not state explicity, that the Pi-sia-ye are a Formosan tribe.[3] His arguments, however, are by no means valid. The Chinese text is not at all ambiguous, and says plainly that it was a country beside or near Formosa, and one with a different language; there is here, consequently, the question of a non-Formosan tribe. In the description of the Formosan tribes, Chinese authors never use the word "country" (*kuo*) as used above in connection with the Pi-sia-ye, but speak only of clans and tribes; furthermore, a tribe of the name Pi-sia-ye has never existed, nor does it exist, on Formosa. The mere linguistic evidence, however (*i. e.,* the phonetic coincidence of Pi-sia-ye and Visaya or Bisaya), is not in itself sufficient proof for assuming the identity of these people with the Philippine tribe of that desig-

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[1] The Languages of China before the Chinese, p. 127.

[2] *T'oung Pao* (1895), vol. VI, p. 182.

[3] James W. Davidson (The Island of Formosa, p. 3) falls into the same error.

nation. Culture-historical considerations must be added to make the evidence convincing.

There can be no doubt that the aborigines of Formosa form part of the Malayan group of peoples; and from the oldest account which we possess regarding them, which is contained in the Chinese Annals of the Sui dynasty, full evidence of the fact may be obtained, that in the beginning of the seventh century, when the Chinese first discovered the island, its culture was of a thoroughly Malayan character. Moreover, it has been observed that the languages of Formosa are more closely akin to those of Luzon than to any other Malayan stock, a large number of words being in common, even terms expressing relationship, and that striking agreements in the two cultures exist; *e. g.*, in the practice of and ideas concerning head-hunting. I am under the impression that Formosan and Philippine-Malayan cultures are only two variations of one and the same North-Malayan culture-type. The fact that the Formosans are immigrants is self-evident and confirmed by native traditions. Theoretically, there are only two ways possible for this immigration: either the Formosans came from the original seats of the Malayan stock or from the direction of the Philippines. I concur with Prof. H. Kern and P. W. Schmidt in the view that the Malayan home was somewhere off the east coast of Farther India—a theory now splendidly corroborated by the discovery by Schmidt of the relationship of the Malayan with the Mon-Khmêr languages. If the Formosans had taken their starting-point from there, they would doubtless have gradually followed the coast-line of the East-Asiatic mainland, and, touching along the shores of China, have reached their present home. Then, however, we should have expected that they would never have lost contact with the continent, and would have had some idea of the Chinese. The fact is, however, that the Formosans never had any cognizance of China, nor the Chinese of them, before the year 607, and at the first military expedition of the Chinese, in 610, the two cultures suddenly clashed like two alien worlds. The reason for this late mutual acquaintance may be sought partly in natural events, as in the fact that the channel which separates the island from the continent is shallow and perilous to navigation, and in that the whole region is the center of typhoons. On the part of the Formosans, the additional fact comes in that they were not and are not skilled seafarers, in contradistinction to their relatives. No Formosan word referring to boat-gear agrees with any Malayan word; their national vessel is still the raft.[1] We hear nothing of ships and maritime enterprises, and it is strange indeed that they never visited the neighboring Chinese coast. This is one of the chief reasons which incline me to think that the tribe which, according to the "Sung-shih," made a piratical move toward Fuhkien at the end of the twelfth century, can not well have been of Formosan origin. If we now consider the only possible way which emigration to Formosa could have taken place—that is, from the Philippines—there is no longer any reason for wondering why the Pi-sia-ye should not have come from the same direction. Formosa can have been populated only from that region; not, however, as the result of a bold seafaring enterprise, but rather, it would seem, through several accidental adventures. In this connection the following incident may be instructive. In August, 1886, some fishermen in the neighborhood of Anping (now Tainan, southwest Formosa) picked up a castaway canoe in which there were three men, two women, and a child in a starving condition. They proved to be natives of an island to the north of Luzon, who had been blown to sea in a typhoon, and had ultimately drifted to the shores of Formosa, having been thirteen days without food, and dependent on rain water for drink.[2] It seems to me quite conceivable that in times gone by people may have thus drifted repeatedly to Formosa from the Philippines, especially from Luzon, making a series of emigrations which finally led to the settlement of the island. Such casual drifting was perhaps the case also with the Pi-sia-ye, who reached Formosa first,

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[1] C. Imbault-Huart, L'île Formose (Paris, 1893), p. 273. Some tribes may have formerly possessed canoes also.

[2] The following case, recorded by Davidson (The Island of Formosa, p. 580), also deserves mention in this connection. The Riru tribe of the Kirai district of the northern Ami (in southeast Formosa) state that their forefathers originally lived in an island to the east of Formosa. One man, called Tipots, and his family were out at sea in two canoes when a terrific gale arose, sweeping them away from their home-land and wrecking them on the coast of Formosa, where they built houses and gave life to the present Riru tribe. This tribe possesses an old canoe which they claim is the model of the one used by their forefathers. At present the village people once a year put the canoe into the sea and mimic the landing of their ancestors. After this ceremony they worship spirits of their departed ancestors. A more fanciful tradition is to the effect that their ancestors came from over the sea on the back of a large tortoise. "Thus it would appear," concludes Davidson, "that the traditions of the north Ami describe comparatively recent occurrences and are in the main very possible, if not probable."

and then, driven away by inhospitable natives,[1] turned to the shores of China. I think that in this manner a rational explanation of the event may be given. The account of the "Sung shih" is certainly incomplete and abrupt; but how should the Chinese, then entirely ignorant of the far-off Philippine Archipelago, have obtained a more detailed knowledge of a handful of people who paid only a flying and hostile visit to their coast? But the brief sketch of them showing their craving for iron, their mode of fighting, their bold Viking raid, is an ethnographical document of great impressiveness. If the identification of Pi-sia-ye with Visaya is justified, we have here the oldest historical allusion extant to a tribal movement and event of the Philippines.

A special section in the "Ming shih" is devoted to the Malayan tribe of the *P'ing-ka-shi-lan,* which I identify with the Pangasinan, who inhabit the western and southern shores of the Bay of Lingayen, on Luzon. Before the Conquest their territory extended much farther northward, but they were gradually repulsed by the Ilocanos. Since 1572 they have been subjected to the Spaniards, and at the present time they are all Catholics.[2] According to the Chinese records as preserved in the "Ming shih" (chap. 323, p. 20), they seem to have formed a small realm of their own in the beginning of the fifteenth century. Their first embassy to China mentioned was despatched in 1406 to the court of the Emperor Yung-lo, whom they presented with excellent horses, silver, and other objects. In return they received paper money and silks. Their second embassy falls two years later, in 1408; and a third was sent in 1410. In the former of these last two embassies the chieftain appeared personally with a large retinue, having selected two men from each village subject to his authority, each of whom led a number of his tribal clan to bring tribute to the court. The Emperor bestowed paper money (*ch'ao*) on the two sub-chiefs, and six pieces of an openwork variegated silk fabric for coats and linings for a group of a hundred men. Their followers also received gifts. In the same year, 1410, another embassy from the Philippines is mentioned, the

[1] Compare especially chapter IX in Davidson's book, "Wrecks and Outrages on Navigators." It must be also remarked that the communication between Formosa and Luzon had no difficulties. According to Davidson (p. 563), the present plains tribes of Formosa, once in prosperous and powerful circumstances, formerly crossed the Bashee Channel to the south and maintained communication with Luzon. The traveling distance from Formosa to Manila is given by the Chinese to be 60 "watches" (*kêng*), *i. e.,* 6 days and nights (*Ming shih,* chap. 323, p. 18 *b*).

[2] F. Blumentritt, Versuch einer Ethnographie der Philippinen, pp. 21-22.

head of which was a high official called Ko-ch'a-lao. He brought with him the products of his country, particularly gold. The natives therefore must be credited with the exploitation of gold before the advent of the Spaniards.[1] This becomes evident also from a passage in the "Wu hsio pien," a history of the Ming dynasty published in 1575. It is quoted in the "Tung hsi yang k'ao" (chap. 5, p. 1) as follows: "Luzon produces gold, which is the reason of its wealth; the people are simple-minded, and do not like to go to law."

As to how far the political influence of the Chinese extended over the Philippines in prehispanic times, we have only scanty information. The "Ming shih" (chap. 323, p. 11 a) relates on this point that in 1405 the Emperor Yung-lo sent a high officer to Luzon, who was to govern the country. The result of his visit was the embassy from Luzon under Ko-ch'a-lao in the same year. How long Yung-lo's delegate remained on the island and of what character his jurisdiction was are not narrated, but it is not at all incredible that the ambitious Yung-lo exercised a kind of supremacy, or at least claimed a prerogative of protection, over the Philippine Islands; for since its establishment the rule of the Ming dynasty has been characterized by a tendency toward expansion, from a desire to extend its fame over land and sea to the farthest extremities of the world.

In Yung-lo's time the Chinese started an extensive exploration of the Indian Ocean. In 1407 the eunuch Chêng-ho undertook a memorable expedition, accompanied by a fleet of sixty-two large ships, carrying 27,800 soldiers; and on his crusades, repeated several times in a space of about thirty years, he visited a number of countries in the Indian Ocean as far as the Arabian Gulf, and obtained the nominal allegiance of their rulers. For this reason the "Ming shih" abounds in geographical and ethnological descriptions of all Asiatic countries and peoples from Central Asia to Asia Minor.

Then Vasco da Gama had not yet navigated around the Cape of Good Hope; no European sail had yet been visible on the Pacific and Indian oceans, of which the Chinese and the Arabs were the unrestricted masters and the only representatives of an immense trade. It therefore seems not impossible that in that great age of maritime discoveries the enterprising Emperor had cast his eyes Philippineward and had won a temporary nominal suzerainty over the native tribes of Luzon.

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[1]Compare M. Sonnerat, Voyage aux Indes Orientales et à la Chine (Paris, 1782), vol. II, p. 114. Also De Morga mentions native gold-mines.

Some of the older Spanish authors also entertained the view that the Philippines were once subject to Chinese rule; and Father Gaubil relates in the *Lettres édifiantes* that Yung-lo maintained a fleet with thirty thousand men, which sailed to Manila at various times.

It was in 1571 that the Spaniards and Chinese met for the first time at Mindoro, before Legazpi, the conqueror of the Philippines, undertook his expedition to Manila.[1] That there was a colony of Chinese on Luzon before the arrival of the Spaniards, there can be no doubt, as it is clearly stated also in the "Ming shih" (chap. 323, p. 11 b), which says that "formerly the people of Fuhkien lived there because the place was conveniently near. They were traders of abundant means, ten thousand in number, who, as a rule, took up a long residence there, and did not return home until their sons and grandsons had grown up. When, however, the Franks snatched away this country, the Spanish king despatched a chief to suppress the Chinese. As he was concerned lest they might revolt, he expelled many of them. All those remaining had to suffer from his encroachments and insults."

According to the Ming Annals (chap. 323, p. 11 a) it was about the commencement of the Wan-li period (*i. e.*, 1573) that the Franks made their first appearance in Philippine waters. There is a curious tradition reported by the Chinese chronicler in connection with the first settlement of the Spaniards and their foundation of the city of Manila. This tradition runs as follows: "The Spanish Franks surpassed the people of Luzon in strength, and for a long time interchanged commerce with them. When they perceived that the country was weak and could be occupied, they bestowed rich presents on the king and demanded a plot of land as big as an ox-hide for building houses and living there. The king did not suspect any trickery, and assented. These men thereupon cut the hide of an ox into narrow strips, pieced these together until they extended the length of a thousand fathoms, and in this way encompassed the whole land of Luzon, which they then claimed, in accordance with their agreement. The king was exceedingly taken aback; but, as he had already given his promise, there was no way out of it but to yield to their demand. Thus these men obtained the land, erected houses, and built a city, where they planted firearms and safeguarded it against the attacks of highwaymen. Finally they took advantage of the king's unpreparedness, came upon him unawares, killed him

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[1] F. Blumentritt, Die Chinesen auf den Philippinen (Leitmeritz, 1879), p. 1.

and his people, and took their country, the name of which was thenceforth 'Luzon-Spanish-Franks.' "[1]

In this tradition a repetition of the classic story of the ruse of Queen Dido in connection with the foundation of Carthage will be recognized at once (see Appendix). That the Chinese tradition regarding the occupation of Manila, however, is not quite without foundation in some details, may readily be seen by a comparison with the Spanish account of Antonio de Morga, whose "Sucesos de las Islas Filipinas" was published in Mexico in 1609.[2] At the Bay of Manila the Spaniards found two fortified towns separated by a large river, each in possession of a chief. The Spaniards entered the town by force of arms, and took it, together with the forts and artillery, on the day of Santa Potenciana (the 19th of May, 1571), upon which the natives and their chiefs gave in and submitted, and many others of the same island of Luzon did the same.[3] Then the commander-in-chief, Legazpi, hurried to the scene from Panay and established a town on the very site of Manila, which the chief presented to the Spaniards for that purpose. In the words of De Morga, *he took what land was sufficient for the city.*

After 1410 no further relations of China with the Islands are recorded until 1576, in which year an imperial army was forced to fight against the corsair *Lin Tao-k'ien* or *Lin-fung.*[4] The inhabitants of the Philippines took an active part in the suppression of the rebels, and, in recognition of the service rendered to them by China, sent an embassy which traveled by way of Fuhkien. The speaker

[1] The *Tung hsi yang k'ao* (chap. 5, p. 1 *b*), after relating the same story, has the following in addition: "The King of Yü-ssŭ la (Islas, *i. e.,* Spain) despatched a chieftain to guard the place. After several years a change in the government took place. The Chinese who formerly traded with Luzon now do their business with the Franks. The Chinese go to Manila in great numbers, traveling to and fro. Those who make a long stay and do not return home are called *Ya-tung* (Cantonese, *At-tung;* literally, 'pressing the winter'). They live crowded together in the *Kan* (*i. e.,* the *parian* of the Spaniards). The number of those born there has gradually increased to tens of thousands. Occasionally there are found among the elder sons and grandsons those who cut off their hair." De Morga remarks that the Christians among the Chinese differ only in that they cut their hair short, and wear hats, as do the Spaniards.

[2] English translation by Lord Stanley, published by the Hakluyt Society (London, 1868). It is this edition to which reference is made in this paper. A new translation has just been issued by Blair and Robertson in two volumes (Cleveland, 1907).

[3] De Morga, p. 18.

[4] By Spanish authors he is called *Limahon,* from the Amoy pronunciation, *Lim-hong.*

of this delegation was a Mohammedan, who probably made himself understood in Arabic through Chinese Mohammedan interpreters, as, add the Annals, was also the custom in Corea.

In 1571, three years after its foundation, Manila was attacked and nearly taken by Lin-fung. The city was saved only by the valor of the hero Salcedo. This event was recorded at great length by the Augustinian monk Fray Gaspar, in his "Conquista de las islas Filipinas," which appeared in Madrid in 1698.[1] The "Ming shih" alludes to Lin-fung only once, in the passage above quoted; but the Chinese Annals of the province of Fuhkien, the Chronicle of Chang-chou, and the "Hai kuo t'u chi"[2] give fuller accounts of his piratical enterprises. The Spanish embassy mentioned in the "Ming shih" as having arrived after the expulsion of the corsair is confirmed by the Spanish documents of the time. The governor, Labezares, considered it his principal task to entertain peaceable and amicable relations with an empire whose pirates alone were able to shatter the Spanish possessions in Asia. He was led to such a policy still more by commercial considerations. The commander of an imperial Chinese war vessel, who had been sent out from Chang-chou to look after Limahon and who was charmed with the chivalrous character and the generosity of the Spaniards, offered to take Spanish envoys over to China in his ship. This embassy consisted of two military officers and two Augustinian friars. The instructions given by Labezares to this mission are not without a tinge of modern politics. He declared to the Viceroy of Fuhkien that the Spaniards were animated by the desire to live on friendly terms with the Chinese Empire, and to promote commerce between the two peoples. He requested that missionaries be admitted into the empire, and particularly that a Chinese port be ceded to Spain, whence, like Portugal in Macao, she could trade undisturbed with China; the envoys to pay attention to the customs and manners of the Chinese, and especially to study what articles of merchandise were best suited for interchange between China and the Philippines and what industrial products of Spain and her colonies would promise a fair market in China. This man, Labezares, was evidently more than three centuries ahead of his time. The embassy was unsuccessful in effecting its object, although it humiliated itself so far as to perform the kotow before the viceroy, and returned to Manila in 1575, accompanied by three Chinese captains who had come to bring Limahon

[1] F. Blumentritt, loc. cit., pp. 5-16.

[2] A geographical work published in 1844 (Wylie, Notes on Chinese Literature, p. 66).

in chains back to their country. These officers carried rich presents to the governor from the Viceroy of Fuhkien. Meanwhile, however, Dr. Francisco de Sande had succeeded Labezares as "Gobernador." The very learned but also conceited Dr. Sande now claimed these presents for himself, while the Chinese declared they were authorized to deliver them only to Labezares. The pride of Sande was sensibly hurt by this little incident, and from that day he showed such an antipathy toward everything Chinese that he endangered the interests of the Spanish Crown by his narrow-minded policy with regard to China.

Fray Gaspar relates that in 1576 a Chinese war junk arrived at Manila with a despatch from the Viceroy of Fuhkien, in which it was stated that the Emperor had read all the Spanish letters of Labezares, and consented to cede to the Spaniards an island between Canton and Pakian under the same conditions as Macao had been turned over to the Portuguese. *This account meets with no confirmation in the Chinese annals.* Sande did not accept this offer, and offended the Chinese ambassadors by not reciprocating the presents sent to him from the Emperor. The brightest idea that dawned on him was to saddle on the returning embassy two monks, who, however, never saw the shores of China. The Chinese had humor enough to unload this clerical ballast at Bolinao, soon after sailing from Manila.

Sande conceived the daring plan of conquering China by force of arms, and deluged King Philip II with a mass of alluring reports depicting in glowing colors the feasibility of such a scheme. These form fascinating reading matter, and are now easily accessible in the fourth volume of Blair's and Robertson's monumental work, "The Philippine Islands." Philip II flatly rejected this project, and ordered Sande to further amicable relations with China; and since that time Spain has taken no further political action toward China.

The *first* great political event related in the "Ming shih" is the rebellion of the Chinese *P'an Ho-wu* in 1593, who stabbed the then Spanish governor, or, as the Annals call him, chieftain, Don Perez Gomez das Mariñas. His name is preserved in Chinese under the form Lang Lei Pi-li Mi-lao, and that of his son as Lang Lei Mao-lin, which is intended for Don Luis das Mariñas. "Lang" is a term of respect, meaning a "gentleman" generally, and evidently represents a translation of the Spanish "Don," while "Lei" seems to stand for Luiz, "Pi-li" for Perez, and "Mi-lao" or "Mao-lin" for Mariñas. The Chinese account of this incident reads as follows:

In the 8th month of the 21st year of the period Wan-li (1593), when the chieftain Don Perez Gomez das Mariñas undertook a raid on the Moluccas, he employed two hundred and fifty Chinese to assist him in the combat. It was P'an Ho-wu who was their lieutenant. The savages lay down, drowsy, in the daytime and commanded the Chinese to row the ship. As they were somewhat lazy, they were suddenly beaten with a whip, so that several of them died. Ho-wu said, "Let us revolt and die in that way. Should we submit to being flogged to death or suffer any other such ignominious death? Should we not rather die in battle? Let us stab this chieftain to death and save our lives. If we are victorious, let us hoist the sails and return to our country. If we should succumb and be fettered, it will be time enough then to die!" Then all of them at night stabbed the chieftain to death, and, seizing his head, shouted in a loud voice at the savages, who were frightened and arose, not knowing what was going on. They were all killed with the sword. Several fell into the water and died. Ho-wu and the others took possession of their gold, valuables, and military armor. Then they prepared the ship for their return, but lost their way, and proceeded to Annam, where they were robbed by the people of that country. Wei-kuo, Wei-t'ai, and thirty-two other men, being near to another ship, seized it; and when they returned (ashore), the chieftain's son, Lang Lei Mao-lin (Don Luis Perez das Mariñas), who stopped at So-wu (*i. e.,* Cebu) learned of the affair from them. Leading his troops, he passed quickly on (to Manila), and dispatched to China a priest to state the wrong done to his father, with the request that the war junk, gold, and valuables be returned, and that those men who had incurred his enmity be executed, and thus offer retribution for his father's life. The (Chinese) governor, Hsü Fu-yüan, informed the governor-general of the two Kuang provinces of the matter through an official communication and politely sent the priest back. They pardoned Wei-t'ai for having arranged this matter. Ho-wu remained in Annam and did not venture to return. This was the first (Spanish) chieftain who had been slaughtered. Those of his division who came down to Manila expelled the Chinese into the outer part of the city. They demolished their huts; and when Mao-lin (Das Mariñas) returned he ordered them to build houses outside of the city, that they might live there together. It is reported that when some pirates once came from Japan, Mao-lin feared they might join with the Chinese, which he considered would be a calamity, and again decided to drive them out. Fu-yüan sent an envoy (to Manila) to invite the Chinese to come back (to China). The barbarians, however, provided the messengers with food for the voyage, and sent them home; for the Chinese merchants, from their love of profit, did not care to risk their lives, so for a long time they again dwelt together in the city.[1]

Antonio de Morga,[2] after describing Mariñas' plan to conquer the Moluccas, thus narrates the events of the expedition:

The governor and those who accompanied him passed the time playing on the poop till the end of the first watch; and after he had gone into his cabin to rest, the other Spaniards went to their quarters for the same purpose, leav-

[1] The same event is briefly alluded to in another passage of the *Ming shih,* where the history of the Moluccas is narrated. In Groeneveldt's translation of this passage (Notes on the Malay Archipelago, p. 118), the erroneous rendering "Portuguese" must in each case be corrected into "Spaniards."

[2] The Philippine Islands (London, Hakluyt Society, 1868), p. 35.

ing the usual guards in the midship gangway and in the bows and stern. The Chinese rowers three days back had agreed to rise up and seize the galley whenever they should find a favorable opportunity, from a desire to save themselves the labor of rowing on this expedition, or from coveting the money, jewels, and other articles of value on board, as it seemed to them ill to lose what was offered to their hands. They had provided themselves with candles and white shirts, and had appointed some of their number as chiefs for the execution of the plan; and they carried it out that same night, in the last watch before dawn, when they perceived that the Spaniards slept. At a signal which one of them gave, at the same moment all put on their shirts and lit their candles, and with their *catans* in their hands they at once attacked the guards and those that slept in the quarters and in the wales ("arrumbadas," planks or frames on which soldiers sleep), and, wounding and killing, they seized upon the galley. But few Spaniards escaped—some by swimming to land, others in the boat which was at the stern. The governor, when he heard the noise in his cabin and perceived that the galley was dragging, and that the rabble was cutting down the awning and was taking to the oars, hurried out carelessly, and his head being unprotected at the hatchway of the cabin, a few Chinese who were watching for him there, split his head with a catan. He fell, wounded, down the stairs into his cabin, and two servants whom he had within carried him to his bed, where he died immediately. The same fate met the servants, who were stabbed through the hatch. The only Spaniards that remained alive in the galley were Juan de Cuellar, secretary of the governor, and Padre Montilla, of the order of Saint Francis, who slept in a cabin amidship; and they stayed there without coming out; and the Chinese did not dare to go in, thinking that there were more Spaniards, until next day, when they took them out, and let them go on the coast of Ylocos, of the island of Luzon itself, in order that the natives might let them take water on shore, of which they were short.

The Spaniards who were in the other vessels, close to land, although they perceived from their ships the lights and the noise in the galley, thought it was some maneuver that was being executed; and when afterwards they knew, after a short space, through those who escaped, swimming, what had happened, they could give no assistance, and remained quiet, as everything was lost, and they were few in number, and not in sufficient force. So they waited till morning, and when it dawned they saw the galley had already set the mainsail, and was sailing wind astern, returning to China, and they could not follow it.

As the wind served, the galley sailed all along the coast of the island until leaving it. It took in some water at the Ylocos, and left there the secretary and the friar. It [the galley] attempted to cross to China, and not being able to fetch it, brought up at the Kingdom of Cochin China, where the King of Tunquin took from them what was in the galley, and two large pieces of artillery which had been embarked for the expedition to Maluco, and the royal standard, and all the jewels, money, and precious things, and left the galley to go ashore on the coast. The Chinese dispersed, and fled to different provinces. The governor, Gomez Perez, met with this disastrous death, with which the enterprise and expedition to Maluco, which he had undertaken, ceased also. Thus his government ended, after he had held it for little more than three years.

* * * In Manila the seizure of the galley and death of the governor became known very shortly, and with this astounding news the townspeople and the men-at-arms, who had remained there, met together in the house of the licentiate, Pedro de Rojas, to treat of what it was fitting to do; and first of all to elect him as governor and captain-general; and then they sent Captain Juan Ronquillo del Castillo, with other captains, in two frigates (for there was no other vessel) in pursuit of the galley; which was fruitless, for they never saw it. In like manner the governor sent to Don Luys Dasmariñas, and to the fleet and army, which was in Pintados waiting for Gomez Perez, advising them of his death, and of what had happened, and of the new election which had fallen upon him for the government, and ordered them to come with all speed to Manila, which was left very much deserted, and without the necessary precautions for anything that might occur.

If the death of the governor, Gomez Perez Dasmariñas, was unfortunate, as much for the loss of him personally as for such a good opportunity having been lost for the conquest of Terrenate, the success of which expedition was held to be certain, the return of the fleet and arrival of the troops in the city was none the less a fortunate event; since not many days later (anticipating the usual time for their navigation), a quantity of ships from China came to Manila with many men on board and little merchandise, and seven mandarins with the insignia of their office. This gave sufficient motive for suspicion that they had had notice of the departure of the fleet to Maluco, and of the city having remained defenceless, and that on this occasion they came to attempt to take the country; from which they desisted when they found the city with more troops than ever, and they returned without showing any particular motive which had brought them, and without any sign of consciousness being given by one side or other. Only the governor, Don Luys, was on the alert and very watchful, and took the proper arrangements, especially with respect to the Chinese and their quarters and parian.

Whilst Don Luys Dasmariñas governed, the suspicions and fear *continued with respect to Japan,* and people lived in anxiety as to that, and on account of the Chinese. The governor sent his cousin, Don Fernando de Castro, to China with letters and dispatches to the Viceroy of Canton and the Viceroy of Chincheo, where it was understood that there were many of the Chinese who had seized upon the galley and killed the governor, Gomez Perez. Supposing that they had gone there with it, a request was made for the guilty to be given up for punishment, and that the royal standard, artillery, and the other things which they had carried off should be restored. This was not obtained, because, as the galley went to Cochin China and the Chinese dispersed in so many directions, it could not be effected, though at the end of a few days a few of the guilty Chinese were brought from Malacca to Manila, whom the captain-major, Francisco de Silva de Meneses, had found there. From these it was known more accurately what had passed with respect to the seizure of the galley and death of the governor, and justice was done upon them.

The fuller account of Antonio de Morga agrees fairly well with the concise Chinese report, except that De Morga neglects to mention the cruel maltreatment of the Chinese sailors, and adduces no other reason for their revolt than their craving for treasure. The

Chinese embassy which he credits with the plan of taking Manila is of course identical with the peaceable envoy of the "Ming shih," whose task it was to bring his countrymen back to China. In this, as in subsequent cases, we find the Spaniards, in their dealings with the Chinese, misinterpreting their motives of action, and in consequence doing them injury and injustice. This was due chiefly to their ignorance of the language and to their lack of well-trained interpreters. From other temporary Spanish records it also becomes evident that Das Mariñas fell a victim to his own rashness and inconsiderateness. He had a large army ready to conquer the Moluccas, but was not able to secure rowers enough for his galleys. He therefore seized by force any Chinese in the parian of Manila he could lay hold of and had them chained to the banks of oars on the galleys. Most of these wretched victims were peaceable merchants and artisans. Besides these, he forced into his service as soldiers a number of Chinese traders and sailors who had just arrived from China. His murder is fixed by the Spanish chroniclers as having taken place on the night of October 25–26, 1593, which tallies exactly with the statement of the "Ming shih;" also the facts there told of the mission of Luis das Mariñas to China to ask indemnity for his slain father are confirmed by the Spanish authors. He returned without having effected his purpose; but the Portuguese gobernador of Malacca sent some of the murderers who had been caught there to Manila, where they were executed. It will be observed that the simple accounts of the Chinese are not valueless either in corroborating or in supplementing the Spanish records, and put in a much clearer and better light the true motives of the Chinese people, which could be but imperfectly understood by the Spaniards of those times.

An instructive example of how myth sometimes develops from history is furnished by Juan de la Concepcion, whose voluminous "Historia General de Filipinas" appeared at Manila in 1788–'92, in fourteen volumes. His account of the Chinese mutiny in 1593 is partial and one-sided. In speaking of the death of the governor, he says the Chinese split his head in two with their *alfanges*. He retired severely wounded, lay down on his bed, took the prayer-book of his order in his hands and an "imagen de Nuestra Señora y con estos consuelos de su piedad, dió su alma al Señor." The older sources relate nothing of such a touching scene, but agree in saying that his head was cut off at a blow.

From an historical point of view, the cruelty of Das Mariñas toward the Chinese, and his death, which resulted from it, form important factors in the long line of relations between China and the West and the opening act in a deplorable series of unjust wars and inhuman outrages. This event, no doubt, must have left a deep and lasting impression on the minds of the Chinese world and furnished good grounds for their prejudices against foreigners. And not only that: the Spanish system of treating the Chinese became the model of the Chinese in their treatment of foreigners. This is expressly stated by an English writer, who remarked seventy years ago,[1] "That the Chinese authorities are not entirely ignorant of the situation of their countrymen at Manila, we infer from the well-attested fact that the system which they have long been endeavoring to impose upon foreigners here [in China] has been borrowed from the Spanish Government. We are informed on the very best authority that Pwankequa, the father of a late well-known senior *Hong* merchant and grandfather of him who bears the same name now, saw there the harsh treatment inflicted on the Chinese in order to keep them in subjection, and marked it as a 'model and motive' to be acted on, after his return to Canton. He was a man of considerable influence in regard to all measures concerning foreigners, and the restriction on their privileges which he caused to be introduced have been gradually becoming more severe since the middle of the last century."

Indeed, if we would fully grasp the innermost causes of the Boxer rebellion, we must go back to the history of the relations of the Spaniards to the Chinese in the Philippines.

When the famous governor, Pedro de Acuña, arrived at Manila, in 1602, trade with China had reached its climax. Yearly thirteen to fourteen thousand merchants assembled at a kind of fair, when with the spring monsoons the large junks came from China. Silks and nankeens, porcelain, copper and iron, besides many other products, were exchanged for Mexican silver. At that time there were, according to Argensola, thirty thousand Chinese settled in Manila.[2] This prosperity was destined not to last, however, for in the following year there appeared in Manila a Chinese mission in search of an El Dorado, an expedition which, though it deserves a place among the wildest and most visionary of quests after gold, yet was fraught with the greatest consequences for the Chinese inhabitants of the country. The story would have a humorous tinge were it not for the fact that the folly of one man cost the lives of twenty-five thousand.

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[1] *Chinese Repository* (1834), vol. II, p. 350.

[2] F. Blumentritt, Die Chinesen auf den Philippinen, p. 23.

Antonio de Morga, an eye-witness, gives an interesting and graphic account of these events in his temporary records.[1] It reads as follows:

In the month of this year of 1603 there entered into the Bay of Manila a ship from Great China, in which, as the sentinels announced, there came three great mandarins, with their insignia as such, and they came out of the ship and entered the city with their suite. They went straight, in chairs carried on men's shoulders, very curiously made of ivory and fine woods and gilding, to the royal buildings of the High Court, where the governor was waiting for them with a large suite of captains, and soldiers throughout the house and in the streets where they had to pass. When they arrived at the doors of the royal buildings, they were set down from their chairs, and entered on foot, leaving in the street their banners, equipage, lances, and other insignia of much state which they had brought; and went as far as a large hall, well fitted up, where the governor received them standing up, the mandarins making many low bows and courtesies after their fashion, and the governor answering them in his. They told him, by means of the interpreters, that the king had sent them, with a Chinaman whom they had brought with them in chains, to see with their own eyes an island of gold, which he had informed their king was named Cabit,[2] and was close to Manila, which was in the possession of no one; and that he had asked the king for a quantity of ships, and that he would bring them back laden with gold; and if it was not as he had stated, let them punish him with death; and they had come to ascertain the truth of the matter, and to inform their king of it. The governor replied to them in few words beyond giving them a welcome, and inviting them to rest in two houses which had been prepared for them within the city, where they and their people could lodge, and that their business would be talked of later. Upon this they went out again from the royal buildings, and at the door mounted their chairs on the shoulders of their servants, who wore colored clothing, and they were carried to their lodgings, where the governor ordered them to be abundantly provided with whatever they required for their maintenance during the time of their stay.

The arrival of these mandarins seemed suspicious, and [it was thought] that they came with a different intention from that which they announced, because, for people of so much understanding as the Chinese possess, to say that the king sent them on this business seemed to be a fiction. Amongst the Chinese themselves, who came to Manila about the same time with eight merchant ships, and those who were established in the city, it was said that these man-

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[1] Hakluyt edition, p. 217.

[2] That is, Cavite, called in the writings of the Chinese Chia-i (in Cantonese, Kia-yit), which is the city of Cavite. The *Tung hsi yang k'ao* (chap. 5, p. 3 b) remarks that it was originally only a mountain, and that the Spaniards had founded a city there from fear of the Red-haired (*i. e.,* the Dutch), and concealed gingals behind the walls; in case pirates appeared, they repulsed them by means of these gingals, but did not venture to oppose them in open attack. According to the same passage, the mountain Ki-i shan mentioned by Chang-Yi as the gold mountain is a mistake for Kia-i or Kia-yit, and would therefore be identical with the mountains around Cavite. This agrees perfectly with the statement of De Morga.

darins came to see the country and its condition, because the king wished to break off relations with the Spaniards, and to send a large fleet before the year was out, with a hundred thousand men, to take the country.

The governor and High Court were of opinion that they should be watchful in guarding the city, and that these mandarins should be handsomely treated, but that they should not go outside of the city, nor be allowed to administer justice (as they were beginning to do among the Sangley[1] men), at which they felt some regret: they were desired to treat of their business, and then return shortly to China, without the Spaniards letting themselves appear conscious or suspicious of anything else than what the mandarins gave out. The mandarins had another interview with the governor, and he said to them more clearly, and making rather a joke of their coming, that it caused amazement that their king should have believed what that Chinaman they had got with them had said; and that even had there been in truth any such gold in the Philippines, the Spaniards would let it be carried away, the country belonging as it did to His Majesty. The mandarins replied that they understood well what the governor explained to them, but that their king had bid them come, and they were bound to obey him, and bring him an answer, and that, having done their business, they had fulfilled their duty and would return. The governor, to shorten the matter, sent the mandarins with their prisoner and servants to Cabit, which is the port, two leagues from the city, where they were received with many discharges of artillery, which were fired at the time they disembarked, at which they showed much fear and timidity; and when they landed they asked the prisoner if that was the island of which he had spoken to the king. He answered that it was. They asked him where was the gold. He replied that all that they saw there was gold, and that he would make it good with his king. They put other questions to him, and he always made the same answers, and all was taken down in writing, in the presence of some Spanish captains who were there with private interpreters; and when the mandarins had ordered a basketful of earth to be taken from the ground, to carry it to the King of China; and when they had eaten and rested, they returned the same day to Manila with the prisoner. The interpreters said that this prisoner had said, when hard pressed by the mandarins to answer to the purpose the questions they put to them, that what he had meant to say to the King of China was, that there was much gold and wealth in the possession of the Spaniards and natives of Manila, and that if a fleet and men were given him, he offered, as a man who had been in Luzon and knew the

[1] The Chinese were called by the Spaniards Sangleyes, derived from a word of the Amoy-dialect, "seng-li," trade. Each Chinese had to pay a head-tax "tribute," not to a Spanish official, but to his "capitan," who was a kind of mayor over the parian, called capitan de sangleyes, or alcalde mayor, and enjoyed a high authority among his countrymen. The wealthy Chinese would pay the tribute for their poor fellowmates. It was the principle of the Spaniards not to meddle with the inner affairs of the parian; the capitan represented the mediator between the Spanish authorities and the Chinese population. Sangley means only "trader, merchant," not "class of merchants," as Schott makes out in a note to Jagor's Reisen in den Philippinen (p. 272), nor "itinerant dealers," as Blumentritt (Chinesen auf den Philippinen, p. 18) explains after Barrantes.

country, to take it, and bring back the ships laden with gold and riches. This, together with what the Chinese had said at first, seemed of much importance, especially so to Don Fray Miguel de Benavides, archbishop-elect of Manila, who knew the language, and that it went much further than what the mandarins had implied. The archbishop, therefore, and other monks, warned the governor and the city, publicly and secretly, to look to its defense, because they held it as certain that a fleet from China would shortly come against it. The governor at once dispatched the mandarins and put them on board their ship with their prisoner, having given them a few presents of silver and other articles, with which they were pleased. Although, according to the opinion of the greater number of the townspeople, the coming of the Chinese against the country was a thing very contrary to reason, yet the governor began in a covered manner to make preparation of ships and other things for the purpose of defense; and he hastened to complete considerable repairs which he had begun to make in the fort of Santiago, at the point of the river, constructing a wall with its buttresses in the inner part of which looks to the parade, of much strength for the defense of the fort.

After the departure of the mandarins, suspicion against the Chinese constantly increased, and an uprising against Spanish rule was imputed to them—a charge heralded, first of all, by the influential clergy, but which was not justified by any plausible arguments. The well-to-do class of the Chinese population had certainly no mind to stake their lives and hard-earned property in a revolution. The preservation of the Spanish possession of Manila was a point of the most vital interest to them, for only under such conditions could they be enabled to amass wealth. If the Philippines should ever come under Chinese sway, trade with the Spaniards would naturally cease, and thus their means of subsistence be cut off. It was only the over-hasty initiative steps and the oppressive measures of the colonial government which incited the Chinese, first of all the proletarian class, to put an end to the unsafe situation by a general riot, into which finally the patricians were also forced, under pressure of a preposterous policy enforced by the mailed fist of the Spaniards.

Since 1598 Manila had also had a colony of Japanese.[1] Acuña summoned the Japanese nobles, and laid before them the question as to what part they would take in case of a Chinese insurrection. Their response was, already known to Acuña, that they would fight by the side of the Spaniards. This secret understanding was promulgated in the parian, where it provoked an indescribable panic. Part of the traders fled, but the majority were ready to kill the

[1] An interesting passage extracted from a Japanese work of travel, and relating to the life of Japanese on Luzon, will be found in the *Journal of the China Branch of the Royal Asiatic Society,* new series (1865), vol. II, pp. 79-80.

Spaniards rather than have the hands of the Spaniards laid on them. In vain now were Acuña's efforts to restore peace. It was already an open secret that the Chinese had fixed the uprising for Saint Francis Day (October 4). A Tagal woman had learned this from her Chinese husband, and betrayed it to her father-confessor, who, of course, had nothing more urgent to do than to inform the Gobernador. Fierce combats during eighteen days followed between the Spaniards and the Chinese, which are full of romantic incident and teeming with merciless massacres. The lives of twenty-three thousand Chinese, according to the Spanish accounts, were sacrificed in the name of His Most Catholic Majesty the King of Spain, and twenty-five thousand according to the "Ming shih;" but in 1604 Chinese trade again flourished, and in 1605 six thousand Chinese again inhabited the parian.[1]

Let us now turn to the account of the Ming Annals, which runs thus:

In 1602 two adventurers, Yen Ying-lung and Chang-Yi, came forward with the assertion that there was a mountain, Ki-i-shan, on Luzon containing gold and silver ore. An exploitation of these mines, so they said, might yield yearly ten thousand taels, or ounces, of gold and thirty thousand taels of silver. This rumor reached the ears of the Emperor Wan-li, who issued an edict that a commission be sent to Manila to verify the truth of this startling news. The court was highly amazed at this decree; and the President of the Imperial Censorate in Peking, Wên Shun-su, was bold enough to memorialize the Throne, and to attempt to dissuade the Emperor from such an erratic act.[2] He clearly set forth the danger of the Emperor's eccentric plan, and pointed out that it would provoke the Spaniards to acts of aggression. "I have heard," he said, "that the city of Hai-ch'êng has a highly developed maritime trade, which amounts to at least thirty thousand taels a year. Its inhabitants make every effort to seek commercial advantages, and it would therefore be utterly unreasonable to sail over the sea to Ki-yi, where I am sure gold and silver are not everywhere to be found, and to employ people there to mine the gold. The disadvantage arising from the carrying out of the imperial

[1] F. Blumentritt, Die Chinesen auf den Philippinen, pp. 26-29.

[2] The Censorate is one of the most curious institutions of administration in China. It is, so to say, a substitute for our modern idea of a constitution. The censors exercise a certain supervision over all deeds of court and provincial officials, and freely denounce to the Emperor any defects in their conduct. They receive, for delivery to the Emperor, appeals either of the people against their officials or of officials against their superiors, and they even have the right to accuse the sovereign and to send him warnings and admonitions. They are inviolable, and cannot be called to account for their official doings. Among the memorials of Chinese censors to the Throne, we find a great many documents which breathe a dauntlessness and frankness of speech worthy of a Cato.

decree is extremely great, and calamities and crimes would be sure to follow the dispatch of an army there."[1]

The governor of Fuhkien was not inclined to go himself, but, compelled by the imperial decree, dispatched the assistant district magistrate of Hai-ch'êng (in Chang-chou fu, Fuhkien), named Wang Shih-ho, with a hundred individuals from the same city, to go to Luzon, together with Chang-Yi, to investigate the matter. When the Spaniards heard the news they were terror-stricken. The Chinese, who had a temporary residence there, thus addressed the envoys: "The Imperial Court has really no other intention than that such perverse evil-doers shall breed trouble!" When the governor came to understand a little the intention of their visit, he ordered the clergy to scatter flowers on the road which the imperial envoys would take, and to treat them with respect. He provided a large escort of soldiers to receive them. Shi-ho and his retinue entered the house of the governor, who entertained them with a feast, and after making inquiries, said, "The Imperial Court sends an embassy with the view of exploring our mountains. Each mountain has its owner. How will you explore them? There are mountains in China; could our country go there and open them? Furthermore, you speak of trees on which gold beans grow. Which is the tree that produces them?" Shih-ho could not answer, and looked at Chang-Yi. Chang-Yi replied, "This entire country is gold. Why is it necessary to inquire for beans?" All, without exception, burst out laughing, seized hold of Yi, and wanted to kill him. The Chinese all requested Shih-ho to return to China. He died heartbroken. The governor of Fuhkien was informed of this, and was requested to pass sentence on Yi for his wild speeches. In the meantime the Spaniards were suspicious that the Imperial Court was secretly planning to raid their country, and that the Chinese settlers were treacherously plotting to kill them. The next year the rumor was circulated that troops were to be detailed to take possession of the country. In consequence of this, prices in the iron market rose considerably. The Chinese, in their craving for profit, exhausted their supplies of iron, selling every inch in their possession. The governor issued an order to have the names of the Chinese registered, and divided them into groups of three hundred men, each group to reside in one building. The Spaniards broke into these houses and slew them. As their intentions thus became clear, the Chinese fled in large numbers to the outlying farms. The governor dispatched troops to attack the multitude. As they had no arms, they were killed. A great number took refuge in the mountains of the interior of Luzon (*Ta lun shan*). The savages followed them thither, assaulted them again, and killed a number. As the troops of the savages met with some resistance in the fight, the governor repented, and sent an envoy to deliberate concerning peace with them. The Chinese, suspecting this to be merely a pretext, threw the envoy down and killed him. The governor fell into a great passion, assembled his army, penetrated the city, and set an ambush, so that a great famine broke out among the Chinese near the city. They descended the hills, attacked the city, and suffered a decisive defeat from the division, which fell out of ambush. The total number of those killed in the successive battles amounted to twenty-five thousand. The governor, after holding an in-

[1] History was to prove that his prediction was right; but at that moment, when the nation was maddened by a thirst for gold, no one paid any attention to the words of the clear-sighted censor.

quest, ordered that the property of all Chinese be plundered, which the soldiers did sincerely, knowing that treasures had been hoarded up by them. The Spaniards sent a letter to the governor of Fuhkien, saying that the Chinese had plotted a rebellion, but had failed in their plan, and that they had already requested the relatives of the dead to depart with their children. The governor, Hsü Hsio-ch'ü, promptly informed the Emperor of the revolt, who, in dismay and affliction, issued a decree that justice be administered to the instigators.

In 1604 (second month) the Emperor held a council, and said, "Yi and his accomplices have deceived the Imperial Court and bred quarrel beyond the sea, in which they caused the death by sword of twenty thousand wealthy merchants. This is a terrible disgrace to our country, and he must atone for this crime with his life. His head, hung on a pole, shall be sent over the sea to the chieftain of Luzon who dared kill the merchants." Accordingly the officials passed sentence on the criminal and made known the Imperial will to the governor, Hsio-ch'ü, who, in response, transmitted an official dispatch to Manila, censuring the perpetrators of the great slaughter and ordering the burial of the dead and the return of their wives and children. After that time the Chinese gradually flocked back to Manila; and the savages, seeing profit in the commerce with China, did not oppose them. For a long time they continued to gather again in the city.

So runs the account of the "Ming shih." We notice that not the slightest mention is made in it of an intended invasion of the Philippines, which existed merely in the imaginations of the frightened Spaniards. Even enlightened Spanish writers admit that the insurrection of the Chinese must be attributed to a panic on the part of the Spaniards which drove the Chinese into revolt. Several other Chinese books speak of this tremendous massacre. The local Chronicle of Hai-ch'êng states that eighty per cent of the Chinese slaughtered at Manila on the occasion were natives of that city, and the year in which it took place was one of dark foreboding, for in the same month a hurricane swept over Hai-ch'êng, which caused the river to rise so high that it flooded the country around and carried away part of the wall and fortifications of the city and drowned thousands of people, with their cattle and property. The Annals of T'ung-an, a city not far from Amoy, likewise mention this hurricane, and attribute it to the machinations of foreign priests at Manila. As we find that the principal instigator of the massacre was, to all appearances, the archbishop of Manila, Don Fray Miguel de Benavides, the historian of T'ung-an certainly comes very near the truth when he "smells a clergyman at the bottom of the affair."[1]

The history of the Chinese on the Philippines up to modern times

[1] G. Phillips, Early Spanish Trade with Chin Cheo (*China Review*, vol. XIX, p. 254).

may now be briefly outlined.[1] In 1639 there was another great rebellion of the Chinese in Manila, still more obstinate and longer than that of 1603. In 1662 Chêng Ch'êng-kung, the famous pirate hero, known to the Spaniards and Portuguese as Kogseng or Koshinga (Koxinga), who drove the Dutch from Formosa and established a kingdom there that he might continue his struggle against the Manchu, sent a letter to the Gobernador de Lara in which he accused the Spaniards of suppressing the Chinese, and demanded that the governor submit to his rule immediately. Upon his failure to do so, the corsair stated that he would come to Manila with his entire force and wipe out the city. His threats caused a panic in Manila, but he died during the preparations for the expedition, and his son and successor to the throne of Formosa concluded a treaty of amity with the Spaniards. Their pent-up anger now burst forth in hatred toward the Sangleys, who were charged with having had an understanding with Koshinga. The parian was pillaged and its inhabitants killed or expelled. Nevertheless the Chinese appeared again, and their settlement was again tolerated. However great the hatred of the Spaniards and Filipinos toward them was, they were conscious of the fact that without Chinese trade and industry the Philippines could not exist. Since the seventeenth century the Philippines have been in decadence, owing to the decline of Spanish power. The consequence was that Manila lost its attractions for the big Chinese capitalists, who preferred to invest their money in the flourishing Dutch colonies, and that after the second half of the seventeenth and eighteenth centuries the Chinese immigrants came from the lowest classes of the coast population of Kuangtung and Fuhkien—"poor devils," whose capital was made up of diligence and thrift only. In 1709 the Chinese were banished from Manila under the pretext that they were carrying off the public wealth; but they did not hesitate to come back again. In the course of the eighteenth century they settled down also in the smaller places on the island of Luzon. In 1747 a royal order for their final expulsion arrived from Madrid, the execution of which was suspended. When the British, in 1762, captured Manila and demanded the surrender of the Islands, the Chinese all joined the English. The governor, Señor Anda, then gave the order "All Chinese on the island to be hanged!" which was conscientiously carried into effect. Many Chinese retreated with the English, after they had returned Manila to the Spaniards on the conclusion of peace. Nevertheless the parian was populated

[1]Compare F. Blumentritt, Die Chinesen auf den Philippinen, pp. 30-33.

again during the next years, though orders were issued from Madrid not to tolerate any settlement of Chinese at Manila. This, like all subsequent ordinances of Spain, was entirely futile in checking Chinese immigration, which continued, in fact, until the end of Spanish rule on the Islands.

That even the present Manchu dynasty still considered the Philippines as one of its tributary States appears from the official work, "Ta Ch'ing hui tien," the rules and regulations of this dynasty, in the section on "Court tribute" (*ch'ao kung*), in which the country of Luzon also figures among the vassals and tribute-bearers of China. It is stated there that it was conquered in the time of the Ming by the Franks, but the name remained unchanged. Trade was interdicted by K'ang-hsi, but resumed again under Yung-chêng.[1]

Toward the middle and end of the eighteenth century a number of small geographical treatises appeared in China which attempt to study the geographical positions and conditions of the islands in the southeastern part of the Pacific by furnishing sailing directions to navigators and describing the peculiar features of the native tribes and foreign colonization. The Philippines were described repeatedly in this period. The most interesting of these little works is the "Hai tao yi chi," by Wang Ta-hai, published about 1791. The author had made a voyage to Batavia in a Chinese junk, and describes many of the Channel Islands from personal observation, and other countries from information gathered from various sources during his travels.[2] As an example of this literature, I will give an abstract of a pamphlet entitled "Records of Manila," written by Huang K'o-ch'ui about 1790. After a brief discussion of the various names under which the Spaniards were known in his time, the author goes on to say that the appearance of these men resembles that of the Chinese. "Their hats," he remarks, "are high and angular, their clothes have narrow sleeves. The articles they make use of in eating and drinking are identical with those of the Dutch. Their silver money, which is current in Fuhkien and Kuangtung, is cast and adorned with the portrait of their sovereign. The island of Luzon is in the southeast of the Fuhkien Sea at a distance of 1,000 li. The number of the native population must be estimated at least at 100,000. The products of this country are gold, tortoise shell,

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[1] G. Jamieson, The Tributary Nations of China (*China Review*, vol. XII, p. 98).

[2] A. Wylie, Notes on Chinese Literature, 2d edition, p. 65. The *Hai kuo wên kien lu* ("Record of What I Heard and Saw of the Sea Countries"), by Ch'ên Lun-kiung, published in 1744, describes the sea route to Luzon (*T'oung Pao*, vol. IX, p. 296).

Baroos camphor, birds' nests, sea-slugs, ebony, redwood, fish, and salt. These are all considered the best beyond the sea. Formerly, at the time of the Ming dynasty, Spain took this country and founded the city of Kuei-tou (Cavite) on the outer lake (*i. e.*, Manila Bay),[1] near the coast of the Western Ocean. They set a guard on the isle of Kêng-i, west from the city, that they might have this territory far and near under their control. The winds are extremely severe."

Now follow some curious remarks on the Catholic religion in Manila. The Spanish monks are designated as the foreign "Buddhist priests" (*fan sêng*)—a term derived from Sanscrit samgha, the Buddhist clergy. "The foreign priests," comments the author, "have established a church," a word which he expresses by *Pa-li yüan* ("a hall of the padres"), *pa-li* reproducing the sounds of the Spanish *padre*. "By means of a waterfall they make a clock strike in the church day and night. At the hours of noon and midnight it strikes the first stroke, and so on until twelve strokes sound, and this is repeated." To make this explanation clear in his language, the Chinaman had a great difficulty to overcome, as his day is divided into twelve parts, each comprising two hours of our time. Then he continues:

They do not sacrifice to their ancestors, but worship only their God *Wei-lo*,[2] and, what is still stranger, the padres forgive people their sins. All the people regard the holy water with great esteem. The corpse of the king of the padres (probably bishop) is fried and turned into fat. A father of the religion superintends the work. If somebody desires to embrace their faith, they order him to take an oath to the effect that his body shall now belong to Wei-lo. After the oath the padre takes the holy water of the corpse and pours it over his head. Therefore it is called the "waterfall" water. At the celebration of a wedding the religious father takes a chain and fastens it around the neck of the man and the woman.[3]

On every seventh day they go to church and beg the padre for forgiveness of sins, and this they call "hearing mass" (*k'an mi-shih*=la misa). There is also a nunnery especially for the administration of funds with which to defray the needs of the country. This nunnery is a strict and dignified institution, and is kept locked, while the men who retire into monastic life enjoy an acknowledged authority and are greatly honored. The daily necessaries of life are transmitted to the nuns by means of a revolving frame like a Chinese

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[1] In Luzon, according to the view of the Chinese author, there are three lakes—an outer, a middle, and an inner one.

[2] This is doubtless intended for Spanish *cielo*. The Annals of Kuangtung give a number of Spanish words in Chinese transcriptions, and write *cielo* with the characters *hsi-lo* (Cantonese, *sai-lo*).

[3] My friend Mr. Bandelier explained to me that this custom is still observed also in remote parishes of Spanish South America.

peck-measure, which is on the wall. Among these women there are those who really desire to enter the monastery for the cultivation of moral conduct.

The sailing-ships made in Spain are extremely large, with very strong sails and spars. They carry guns and cannon, which are kept in readiness so that pirates can not come near them. The people of Luzon avail themselves of the sextant, which reflects the surface of the water, shallow stones, and deep-lying rocks. There is nothing that the sextant can not penetrate. This method is more convenient and admirable than the compass. Whenever the people of Luzon are guests of the Chinese they constantly make merry. Their ships are supplied with oars, and it is pleasant to note how clever they are in steering. The large sailing-vessels that come to Manila take three months for their voyage up to the time of landing. When these boats return to their home country, the nature of the water is not the same, and it is necessary to reckon five months for the voyage. The Chinese have now for a century been in mutual commercial intercourse and peace with them. In the period K'ien-lung (1736-'95) the red-haired Ying-kuei-li (English) suddenly dispatched over ten ships straightway to oppress Manila. They desired to occupy this country and to convert the people. The padres were willing to pay them off with presents, and thus got free from the English in a courteous manner.[1] The English thereupon turned to China for trading purposes. Such are the records of Manila.

In a Chinese album containing wood engravings of ethnical types, the "Huang ch'ing chih kung t'u" (*i. e.*, "Pictures of the Tribute-Bearing Peoples of the Manchu dynasty"), published in 1752 by order of K'ien-lung, we find in the first book (p. 70), among other types of European nations, the portrait of a Spanish Jesuit and a nun, as well as that of a Spaniard from the Philippines, styled "barbarian from the country of Luzon," and a woman ("barbarian woman") as his counterpart. These two plates are accompanied with the following flattering explanation:

Luzon is situated in the Southern Sea. It is very near to Chang-chou, in Fuhkien Province. In the commencement of the Ming period it sent tribute to court. In the period Wan-li it was the Franks (Spaniards) who absorbed this country and forthwith gave its name to it. The Franks, being in the southwest of Cambodia, had formerly exterminated Malacca, and then divided the Moluccas with the Dutch (Red-Hairs) until they broke into Luzon. Their wealth and power increased more and more by sojourning in Macao and trading there. The barbarians inhabiting Luzon (*i. e.*, the Spaniards) are of tall stature, and have high noses, pupils like those of cats' eyes, a mouth like that of a hawk, and their clothing is much adorned. They are identical with the people of Spain and Portugal, in Europe. The women coil the hair, in which hairpins are here and there displayed, and wear ear-rings. The neck is bare, and around the breast they wear a short tunic.

[1] The statement is correct in so far as, after the capture of Manila by the British (1762), the private property of the inhabitants was saved from plunder on condition that a ransom of a million pounds be paid, half of which was in money, and the other half in notes on the Spanish Treasury.

They have long petticoats, underneath which they wear a sort of round framework of two or three strips of rattan, one above another (probably identical with the old-style hoopskirt). Over the coil of hair they always wear a net.[1]

Two very curious observations with regard to natural history in the Philippines are recorded in a small geographical work, "K'un yü t'u shuo," published (in Chinese) by the Jesuit father Ferdinand Verbiest, about 1673, in which he followed principally a geography of the world written by Pantoja, an Italian Jesuit, in compliance with an imperial order, half a century earlier.[2] The passage reads as follows:

In the southeast of Kuang-chou, Luzon is situated. This country produces falcons. When the king of the falcons flies up, the flock of other falcons follow him to take birds and animals as booty. The king of the falcons first takes the pupils out of the eyes of these animals, and afterwards a covey of hawks devour their flesh. Furthermore, there is a tree there which animals are not able to go near. As soon as they pass it they fall down dead at its foot.

Whether these statements have any foundation in fact, I am not now prepared to say.

After the Spaniards had been unsuccessful in establishing direct commercial relations with China in the port of Amoy, the people of Hai-ch'êng sent their junks to Manila, and extensive trade was carried on between the two cities. The bulk of Chinese merchandise, the chief article of which consisted in silk, pottery, and metal-ware, was made over to the ports of New Spain and Peru, which thus became a large market for Chinese manufactures. This trade was a source of immense profit to China. The importation of silver into Manila from Spanish America during two hundred and fifty years of intercourse (1571–1821) is computed by De Comyn at four hundred million dollars; and a large share of this, perhaps half, passed over to China.[3]

The entire Spanish colony subsisted until the nineteenth century

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[1] This is the well-known silk net called by the Spaniards redecilla.

"The women wear no caps, but tie a kind of network silk purse over their hair, with a long tassel behind, and a ribbon tied in a bow-knot over their forehead. This head-dress they call redecilla, and it is worn indiscriminately by both sexes" (Richard Twiss, Travels through Portugal and Spain, in 1772 and 1773 [London, 1775], p. 33).

[2] A. Wylie, Notes on Chinese Literature, 2d edition, p. 58.

[3] *Chinese Repository,* vol. VIII, p. 173; see also G. Phillips, Two Mediæval Fuhkien Trading Ports (*T'oung Pao* (1895), vol. VI, p. 456).

exclusively on the Chinese trade.[1] Despised, hated, and feared as the Chinese were, they were nevertheless indispensable to the Islands, and were practically their masters and rulers from an economical viewpoint. The boots made by Chinese shoemakers in Manila were so low in price that they could be sold with a large profit in New Spain. As early as 1603 De Morga wrote:

> It is true that the city can neither go on nor maintain itself without these Chinamen, because they are the workmen in all employments. They are very industrious, and work for moderate wages.

After the great massacre of 1603 the Spaniards felt keenly the lack of the Chinese. There was no food to be found to eat, nor shoes to wear, not even for very exorbitant prices. "The native Indians," laments the chronicler, "are very far from fulfilling these offices, and have even forgotten much of husbandry, the rearing of fowls, flocks, cotton, and the weaving of robes, which they used to do in the times of their paganism."

De Morga gives a most extensive account of the manner of Chinese trade, of the articles traded, of their transshipment to America, and of the conditions of the life of the Chinese in the Philippines. To enter into a discussion of this subject is beyond the scope of the present paper; but I cannot refrain from relating a humorous incident which occurred in the history of early Spanish-Chinese trade. It is taken from a tract printed in Mexico in 1638 and embodied in Thevenot's "Voyages Curieux." These Chinese, says our authority, were so eager for gain that if a particular article of merchandise was a success one year, they tried the market again with it the follow-

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[1] In Pieter Nuyts' (Dutch Governor of Formosa) Report on the Chinese Trade to the Governor-General and Councillors of the United East India Company, written in 1628, it is aptly remarked: "It is, indeed, certain that the only support of the Spaniards and Portuguese in India is the China trade. The wars we [*i. e.,* the Dutch] have everywhere waged against them, with the disgrace they have come to in Japan, have so weakened them, and ruined their trade in other countries, that there is no other place except China where they can make any profits worth mentioning. Accordingly, if we could succeed in depriving them of this trade, or at least in lessening their profits from the same, as we have often done elsewhere, they would be compelled to abandon their best settlements, such as Macao, Manila, Malacca, and Timor; while their factory at Moluccas would lapse of itself. The authorities at Manila clearly see this," etc. (Wm. Campbell, Formosa under the Dutch [London, 1903], p. 53). About the same time, the merchants of Amoy petitioned the authorities, complaining that the Dutch, by their constant attacks on vessels trading with the Spanish, had completely destroyed the lucrative trade formerly carried on beween Amoy and Manila (James W. Davidson, The Island of Formosa, Past and Present [London, 1903], p. 12).

ing year. A Spaniard who had lost his nose got a Chinaman to make him a wooden one to hide his deformity. The artist made such a splendid imitation that it pleased the Spaniard immensely and induced him to pay him the exorbitant sum of twenty dollars for it. The Chinaman, lured by the large sum paid to him, loaded a ship the following year with wooden noses, and returned to Manila with great expectations. Matters, however, did not turn out at all as he had anticipated, and he was only laughed at for his trouble; for, in order to have found a market for this new merchandise, it would have been necessary to have cut off the noses of all the Spaniards in the country.[1]

Regarding the mode of Chinese-Spanish commerce, the "Tung hsi yang k'ao" (chap. 5, p. 6 a) has the following:

As soon as the (Chinese) ships arrived they sent out men to hurry with all dispatch to the chieftain (*i. e.*, the governor of Manila) to bring him presents of silk. The duties which they levied were rather high,[2] but the meshes of their nets were so close that there was no escape. Our people who have intercourse with them remained there without returning home, for the reason that they had the advantage of being but a short distance off and they quickly made money. There was much opportunity for quarrels, but later on they became more cautious. Our people at home were anxious lest the emigrating class might be too numerous there and after their return later on breed rebellion. It was therefore ordered that each junk should carry only two hundred men, and that the number of junks sailing should not exceed a fixed number. Returning home and sailing out again, the number of men was increased to four hundred, the number of ships remaining the same. When our people put to sea many gave a false name and figured only as a number. While their investigation was going on they suddenly escaped in the midst of it and went back to that country. The name of the market is *Kan nei.*[3] Formerly it was within the city; afterwards, when they (*i. e.*, the Spaniards) became suspicious, they transferred it to the outskirts of the city and founded a new *Kan.*[4]

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[1] *China Review,* vol. XIX, pp. 245-246.

[2] According to De Morga, the duty was 3 per cent.

[3] The term by which the Chinese quarter in Manila is designated, the *parian* of the Spaniards. *Kan* is the Cantonese pronunciation of North Chinese *chien* (Giles' Dictionary, No. 1603), and means "a mountain torrent;" *Kan nei,* "inside of the mountain torrent."

[4] "To Manila, all Chinese wares are openly sent from China in Chinese junks which pay export duty to the Emperor of China; and, in order to attract Chinese merchants and secure a monopoly of trade, the Spaniards were in the habit of advancing large sums of money, but the Chinese often failed to return with the value in goods. This went on for several years, till we settled here and the ravages of the pirates began; whereupon Chinese vessels were first kept at home, and then gradually began to visit us, so that during the last few years very little trade has been carried on at Manila." Thus wrote Pieter Nuyts as early as 1628 (Wm. Campbell, Formosa under the Dutch, London, 1903, p. 52).

The following localities which I am able to identify are mentioned in the "Tung hsi yang k'ao":

Ta-Kiang (*i. e.*, "the great harbor," "the great Manila Bay") is the very first place reached in coming from the Eastern Ocean. A great government board is established there, and a city built of stone. The Franks guard this place under the rule of a chieftain. Rice and grain grow plentifully; but the only other products are objects made of leather and horn. Before the bay is reached, the Pi-kia-shan [1] is visible.

Nan-wang is contiguous to Ta-Kiang. In passing farther along, there are two tiny villages, Wei-mi-yen and Wei-yen-t'ang, which produce leather, horn, and cotton.

Tai-mei Kiang enters with sinuous windings into the configuration of the land, and is therefore called Tortoise-shell Bay (*tai-mei wan*). It is surrounded by a mountain which serves as a land-mark. All ships sailing to Luzon must observe this sign-post and steer towards it. This mountain is thus set up like a guard. Although the name "Tortoise-shell" is given, tortoise-shell is not produced there, but the only product is sappan-wood.

Lü-p'êng [2] is southward from Luzon, and produces univalve and bivalve shells.

Mo-lao-yang [3] is situated behind Manila, and produces cotton, oil, hemp, and cocoanuts.

There are some other localities mentioned and described in the same work, but as I am still doubtful in regard to their identification, I must leave this for some other occasion.

There are three anthropological problems which must be taken up in considering the relations of the Chinese to the Philippines. The first is a question of physical anthropology, an investigation of which should show what proportion of Chinese blood is contained in the races and tribes at present inhabiting the Islands. Through intermarriage of the Chinese with Malayan women, a class of half-bloods has arisen whom the Spaniards call Mestizos de Sangley, or Mestizos chinos. They are described as people of tall stature, of sturdy build, intelligent, and possessed of the keen commercial abilities of their fathers. The retail trade of the country and the small banking business are largely in their hands. According to the views of many writers, the Igorrotes on Luzon of the present day represent a mixed race, the descendants of wild mountain tribes and those Chinese pirates who escaped the sword of the Spaniards after the expulsion of the great corsair, Limahon, in 1574. This, like many

[1] *Pi-kia* is a frame of porcelain, brass, copper, or crystal, on which to rest writing-brushes, usually made in the shape of cragged mountains; mountains, therefore, are again compared with this object. *Shan* means "mountain."

[2] Apparently identical with the Island of Lubang, discovered and conquered by Salcedo in 1569.

[3] I think that the identification of this name with *Morong* would be justifiable.

other problems, should be solved by extensive physical research. An ethnological question of great importance would be a study of the traces of Chinese material culture, still remaining, in the life of the Philippine tribes. Such research requires, of course, a deeper knowledge of Philippine ethnology than is available at present, and more extensive and better-classified collections than are now at our disposal. From a cursory inspection of the Philippine material in the American Museum of Natural History, in New York, it seems to me that Chinese influence is particularly to be observed in connection with the industrial crafts of the Christian peoples, as in agriculture, fishery, navigation, pottery, and weaving. The types of Philippine footgear almost seem to be derived from China.

Another important problem in connection with the history of Chinese-Spanish-American trade would be to determine what influence objects of Chinese culture may have had on the peoples of Mexico and Peru. This question has been ventilated by Dr. Walter Hough, in his paper "Oriental Influences in Mexico."[1] Dr. Hough refers to a number of useful plants which were at that time introduced from the East into Mexico, probably by way of the Philippines, like the cocoanut, the banana, the plantain, the mango, and others.[2] He mentions, further, some evidences of contact in the industrial arts, as the making of palm-wine, the close resemblance in construction and shape of the rain-coats used in Mexico to those of China, and other items. To obtain a satisfactory solution of this problem, first of all, the ancient Spanish sources on South America and Mexico should be diligently searched for all references concerning early Chinese trade and imports; secondly, such remains of these as exist should be eagerly sought for and collected, particularly in the line of ceramics and textile manufactures;[3] and, finally, the actual influence, if any, of these on the corresponding industries of American peoples should be investigated.

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[1] *American Anthropologist,* 1900, pp. 66-74.

[2] See, however, O. F. Cook (The Origin and Distribution of the Cocoa Palm, *Contributions from the U. S. National Herbarium,* vol. VII, No. 2, Washington, 1901, p. 259), who contradicts this view. The cocoanut-palm is doubtless indigenous in America.

[3] The following notice is interesting in this respect: "Grau y Monfalcon in 1637 reported that there were 14,000 people employed in Mexico in manufacturing the raw silk imported from China. This industry might be promoted by the relaxation of the restrictions on trade. It would also be for the advantage of the Indians of Peru to be able to buy for five pence a yard linen from the Philippines, rather than to be compelled to purchase that of Rouen at ten times the price" (from Documentos inéditos del archivo de Indias, in Blair's and Robertson's The Philippine Islands, vol. I, p. 69).

APPENDIX

THE DIDO STORY IN ASIA

The above Chinese account of the foundation of Manila through the Spaniards (p. 259) contains the well-known ruse of Queen Dido in connection with the founding of Carthage.[1] This is not the only case of its record in Chinese literature. E. Bretschneider[2] refers to Du Halde's La Chine (vol. I, p. 185), where the same tradition is repeated with reference to the settling of the Dutch on the Island of Formosa in 1620. Du Halde's account is drawn from a Chinese source, the "Annals of Formosa" (T'ai-wan fu chi), which imputes the Dido trick to the Dutch. James W. Davidson[3] reproduces the story, and inclines to see in it an actual historical event. It is certainly far from this. In the Dutch sources regarding the history of Formosa, nothing of the kind is to be found. We have here nothing more than a simple tale, which has spread over almost the entire continent of Asia; and it is most curious to note that in nearly all cases the Asiatic peoples with whom the story is found make the tricksters some European nation who were then invading their country. This is sufficient proof to show that this is the case of a comparatively recent story-migration, which is further evidenced by its absence in any Asiatic literary records of earlier date.

The first to call attention to the wide diffusion of the Dido story was Reinhold Köhler.[4] The same subject was taken up by Henri Cordier,[5] Raoul Rosières,[6] René Basset,[7] and N. Katanof.[8] Despite

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[1] See O. Rossbach, Dido (Pauly's Realencyklopädie, vol. IX [Stuttgart, 1903], pp. 426-433); Meltzer, Dido (Roscher's Lexikon der griechischen und römischen Mythologie [Leipzig, 1885], col. 1012-1018).

[2] *China Review*, vol. IV, p. 386; and Mediæval Researches from Eastern Asiatic Sources (London, 1888), vol. II, p. 319.

[3] The Island of Formosa, Past and Present (London and New York, 1903), pp. 12-13: "The wily Dutchman, with an old trick in mind, proceeded to cut the ox-skin in very long narrow strips, and, after fastening them together, produced a line of sufficient length to surround a vast plot of ground, while the Japanese were struck dumb with astonishment."

[4] Sagen von Landerwerbung durch zerschnittene Ochsenhaut (Th. Benfey's *Orient und Occident*, 1864, vol. III, pp. 185-187).

[5] La légende de Didon (*Revue des Traditions populaires*, 1887, vol. II, pp. 295 and 354); further parallels by Sébillot (*ibid.*, p. 355).

[6] *Ibid.*, vol. VI, pp. 52-54.

[7] *Ibid.*, vol. VI, pp. 335-338.

[8] Türkische Sagen über Besitznahme von Ländern nach Art der Didó (*Revue orientale*, [Budapest, 1902], vol. III, pp. 173-179).

the great zeal of these authors in collecting the material in question, I have found several versions myself not recorded by any of them. Two ways for the migration of the tradition from Europe into Asia are discernible—a land route and a sea route. From Byzance, where it was well known, it seems to have wandered into Russia, and from the Russians to the Ugrians and the Turkish tribes of Siberia. Among both Ugrians and Turks, the tricksters are the Russians. The Syryän tell of the foundation of Moscow in the same way as the Chinese that of Manila, and explain the name of the city by the word "Mösku," which in their language means "a cowhide."[1] The Cheremiss also have it in regard to the Russians, and the Russian farmers themselves relative to a wealthy land-owner of their own. Three Turkish versions have been noted by W. Radloff;[2] others are known from among the Kirghiz and Yakut, and from Tashkend and Hami.[3] Through the medium of European nations, the story seems to have spread over the regions around the Indian Ocean in the sixteenth and seventeenth centuries. In India the foundation of Calcutta is connected with it.[4] In Burma, Adolf Bastian[5] has recorded it. In this case the trickster is a female slave of the Burmese king Dwattabong. When the Portuguese penetrated into Cambodia, in 1553, they employed the same trick of cutting a buffalo hide, according to the tradition of the Cambodians.[6] Finally we find it current among the Chinese, as already stated.

There are two points of interest in the dissemination of this story: First, it affords one of the few examples of a Western tale spreading to the extreme East, while as a rule the stream of folk-lore flowed from east to west in the old world; secondly, it shows that the transmission of folk-lore still goes on, even in recent times, by mere oral accounts. While in almost all cases where folk-lore is handed over from Asia to Europe we have been able to trace the fact of migration back to written sources transferred from nation to

[1] J. A. Sjögren, Gesammelte Schriften, vol. I (Historisch-ethnographische Abhandlungen über den finnisch-russischen Norden [Petersburg, 1861], p. 301).

[2] Proben der Volkslitteratur der türkischen Stämme Süd-Sibiriens, vol. IV (Petersburg, 1872), pp. 11-12, 139-141, 179-181.

[3] See Katanoff, loc. cit.

[4] J. Todd, Annals and Antiquities of Rajasthan (London, 1832), vol. II, p. 235. Regarding a Tibetan legend containing the same motive see Sylvain Lévi, Le Népal, vol. II (Paris, 1905), p. 7.

[5] Die Völker des östlichen Asiens, vol. V (Die Geschichte der Indochinesen, p. 25).

[6] H. Cordier, loc. cit.

nation, and extant in polyglot translations, there is no such written testimony for the legend of Dido in any Asiatic literature to which, as the starting-point, all the current versions could be reduced. Thus we are led to presume, especially because of the introduction of Europeans into the plot, that its occurrence in southern and eastern Asia is due to the oral stories of European sailors and merchants, who had probably imbibed it during their school-days, while its propagation in Siberia seems to have emanated from the mouths of vagrant Russian adventurers.

It may not be without interest to American readers to repeat here some American parallels of the Dido story once discussed by the great linguist, Pott. In his essay, "Etymologische Legenden bei den Alten" (in the Journal *Philologus,* 1863, Supplementary vol. II, p. 258), he quotes from a work by Kottenkamp (Die ersten Amerikaner im Westen, p. 382) the following: "The Indian reminded us of the fraudulent procedure which had once been practised from Pennsylvania against the Delawares. The whites had purchased a plot of land not larger than they would be able to encompass with a cowhide, and the Delawares had been infatuated by the appearance of the small area. The whites, however, cut up the hide into thin strips and covered a space a thousand times larger than the deceived Delawares had sold." To this, Pott remarks in parentheses, "Whether a white exploited in such a way the tradition of Dido which he had learned in school, by transforming poetry into prose and serious reality, may remain undecided. This matter, however, has been told by Indians on the occasion of the foundations of various establishments by Europeans. Thus this trick of land acquisition on the part of the Dutch at their first settlement in the State of New York has been related by Iroquois to subsequent travelers; likewise the story of the same swindle served for the provocation of the Ohio Indians in those times of which we speak."

NOTES

Jamestown Exposition

The act of Congress approved June 30, 1906, authorizing an exhibit by the departments and bureaus of the Government at the Jamestown Exposition, appropriated the sum of $200,000 to be expended under the direction of the Jamestown Tercentennial Commission, consisting of the Secretaries of the Treasury, War, and Navy departments, who were authorized to prepare, transport, and arrange said exhibit. There was also appropriated at the same time $350,000 for the erection of the necessary buildings. The act also provided that the Smithsonian Institution and National Museum should exhibit such articles and materials of an historical nature as would serve to impart a knowledge of our colonial and national history.

The Secretary of the Smithsonian Institution appointed Mr. W. de C. Ravenel, administrative assistant, U. S. National Museum, as the representative of the Smithsonian Institution and National Museum on the Government Board, which was created by the commission, and charged with the preparation of the Government exhibit. Of the total appropriation of $200,000, $16,000 was allotted by the commission to the Smithsonian Institution and National Museum for the preparation of its exhibit, and a separate building, known as "Annex B" and connected with one of the main buildings, was provided for that purpose. The building is 100 feet long by 60 feet wide and contains about 6,000 square feet of space.

In October the following general plan of exhibits was submitted by the representative, with the advice of an advisory committee appointed to assist him, consisting of Dr. Cyrus Adler, Assistant Secretary of the Smithsonian Institution; Mr. W. H. Holmes, Chief of the Bureau of Ethnology, and Mr. A. Howard Clark, Curator, Division of History, U. S. National Museum. The plan was approved by the Secretary and the work of preparation immediately begun.

1. A chronological wall exhibit extending entirely around the building, mainly pictorial, illustrative of American history, as follows:

(*a*) A continuous series of portraits of persons prominent in colonial and national history, beginning with Columbus and ending with Theodore Roosevelt.

(*b*) A series of historical paintings, pictures and maps, chronologically arranged.

2. Statuary.

3. In the center of the building a life-sized lay figure group depicting Captain John Smith trading for corn with the Powhatan Indians.

4. A series of floor cases, containing life-sized lay figures in the costumes of the peoples most prominently concerned in the settlement of the United States.

5. A series of cases containing material illustrating the following periods in the history of the United States: Colonial period, periods of the Revolution, War of 1812, Mexican War, and War with Spain.

6. Models of the Viking ship and the Columbus ships.

7. Models of the *Susan Constant,* the *Half-Moon,* and the *Mayflower.*

8. Models of John Fitch's steamboat *Clermont* and others.

9. Historic medals of the United States and its money.

10. A series of models illustrating the development of land transportation, particularly the railway locomotive.

11. A complete historical series of firearms used in this country.

12. Models of important inventions, such as the telegraph, telephone, electric appliances, etc.

13. History of photography.

14. History of medicine in America.

On April 26, when the exposition was opened by the President, the exhibits were all installed and labeled and the building opened to the public.

A catalogue of 71 octavo pages has been published by the Institution, containing a detailed account of the exhibits.

Bordeaux Exposition

The United States exhibit at the International Maritime Exposition, opened in Bordeaux, France, May 1, 1907, to commemorate the inauguration of steam navigation by the American inventor, Robert Fulton, has been collected and installed, in accordance with official request, under the direction of the Smithsonian Institution. From the congressional appropriation of $15,000 an American pavilion has been constructed, modeled after the central portion of the White House, and the running expenses of the exhibit paid. Mr. W. de C. Ravenel, administrative assistant, U. S. National Museum, appointed to gather, transport, and set up the exhibit, secured many photographs and models of work and apparatus from the various executive departments, as well as relics of Robert Fulton furnished by his grandson, Robert Fulton Ludlow. A collection of models illustrating modes of aboriginal American water transportation, models of famous American steam craft, and a number of interesting photographs, are among the articles on exhibit by the National Museum.

Zoölogical Congress

The Seventh International Zoölogical Congress met for the first time in America at the Harvard Medical School, Boston, Mass., August 19 to 23, 1907. Over five hundred men of science attended the Congress, of whom about one-quarter were from abroad. The Smithsonian Institution was represented by Dr. Richard Rathbun, Dr. Theodore Gill, and Dr. W. H. Dall; the National Museum by Dr. F. W. True, Dr. Leonhard Stejneger, and Dr. H. G. Dyar, and the National Zoölogical Park by Dr. Frank Baker. The program included over 300 papers, read before the several sections.

After the official session in Boston, the members devoted about ten days to visiting the principal biological experimental stations, museums, and universities in the Eastern States, completing their itinerary by a visit to Washington, where they spent several days examining the various public and scientific institutions.

Journey into the Interior of Liberia

The Smithsonian Institution has received from the Department of State copies of two dispatches from Mr. Ernest Lyon, minister resident of the United States at Monrovia, dated March 2 and 5, 1907, giving an account of a journey by him to the interior of Liberia.

He describes the Cavalla as "a beautiful and picturesque stream, with a powerful current sweeping toward the ocean. * * * The country on either side of the river is hilly and covered with immense forests of very valuable timber. Native farms attest the fertility of the soil. This river forms the boundary between Liberia and French territory, and there is no reason," says Mr. Lyon, "why it should not be one of the most important waterways on the west coast of Africa."

From Nyanka Mr. Lyon continued his journey, with a caravan of 30 men, northwest, via the Kelipo Mountains, to Gedibo; thence "northwest through the forest to Pahn, and through Pahn to Grabo about 135 miles to Nyanka. * * * Ten days were consumed on the march from Nyanka to Gedibo, walking every step of the journey, on an average of 8 hours a day, passing through the territory of four different tribes, each with its own tribal dialect, though ethnically they all belong to a common stock, the Grebo, and a knowledge of this tongue is the key to all." The four tribes in about 100 towns aggregate 86,000 population. The men are described as unusually large, powerful, and well built. Many of the men speak English, acquired on their trading journeys to the coast, but they are careful not to impart this language to the women, lest they become too wise and ungovernable.

Mr. Lyon describes some of the principal towns visited and comments on the pursuits, manners, and customs of the people.

PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

CONTINUED FROM LIST IN QUARTERLY ISSUE, VOL. IV, PART I

No.	*Title.*	*Series.*	*Price.*
1717	STIMPSON, WM. Report on the Crustacea (Brachyura and Anomura) collected by the North Pacific Exploring Expedition, 1853–1856	M.C. XLIX	.75
1718	ANDREWS, E. A. The young of the crayfishes Astacus and Cambarus	C.K. XXXV	.35
1719	Twenty-fourth report of the Bureau of American Ethnology, 1902–1903.		
1720	Samuel Pierpont Langley memorial meeting, December 3, 1906: Addresses by Dr. A. D. White, Prof. W. H. Pickering, and Mr. Octave Chanute	M.C. XLIX	.10
1721	McADIE, A. G. Catalogue of earthquakes on the Pacific coast, 1897–1906	M.C. XLIX	.15
1722	Classified list of Smithsonian publications available April, 1907.		
1723	CLARK, HUBERT LYMAN. The Apodous Holothurians: A monograph of the Synaptidæ and Molpadiidæ, including a report on the representatives of these families in the collections of the U. S. National Museum. (*In press.*)	C.K. XXXV	
1724	MÜLLER, BRUNO. The Air-sacs of the pigeon. (*In press.*) Hodgkins Fund.		
1725	Smithsonian Miscellaneous Collections (*Quarterly Issue*), Vol. IV, Part 2 (containing Nos. 1726-1735). 1907	M.C. L	.50
1726	LYON, M. W., JR. Notes on a small collection of mammals from the province of Kan-Su, China. (*Quarterly Issue.*) 1907	M.C. L	.05
1727	DALL, WM. H. Descriptions of new species of shells, chiefly Buccinidæ, from the dredgings of the U. S. S. "Albatross" during 1906 in the Northwestern Pacific, Bering, Okhotsk, and Japanese seas. (*Quarterly Issue.*) 1907	M.C. L	.05
1728	GILL, THEODORE. The Lumpsucker; its relationship and habits. (*Quarterly Issue.*) 1907	M.C. L	.05
1729	WIGHT, W. F. A new Larch from Alaska. (*Quarterly Issue.*) 1907	M.C. L	.05
1730	PIPER, CHAS. V. New plants of the Pacific Slope, with some revisions. (*Quarterly Issue.*) 1907	M.C. L	.05
1731	MERRILL, G. P., and TASSIN, W. Contributions to the study of the Canyon Diablo meteorites. (*Quarterly Issue.*) 1907	M.C. L	.05
1732	WALCOTT, C. D. Louis Agassiz. (*Quarterly Issue.*) 1907	M.C. L	.05
1733	RICHARDSON, HARRIET. Terrestrial isopods of the genus Eubelidæ, collected in Liberia by Dr. O. F. Cook. (*Quarterly Issue.*) 1907	M.C. L	.05
1734	LAUFER, BERTHOLD. The relations of the Chinese to the Philippine Islands. (*Quarterly Issue.*) 1907	M.C. L	.10
1735	Notes to *Quarterly Issue,* Vol. IV, Part 2.		

VOL. 50 1907

SMITHSONIAN MISCELLANEOUS COLLECTIONS

VOL IV QUARTERLY ISSUE PART 3

EXCAVATIONS AT CASA GRANDE, ARIZONA, IN 1906-07

BY J. WALTER FEWKES

INTRODUCTION [1]

Casa Grande is an Indian ruin of undetermined antiquity situated in Pinal County, southern Arizona, a little more than a mile from the left bank of the Gila River. It lies twelve miles from Florence and about eighteen miles from the Casa Grande station on the Southern Pacific Railroad. Casa Grande was given its name about 1694 by its discoverer, the celebrated Jesuit, Father Eusebio Francisco Kino, and has been repeatedly described and figured since that zealous and intrepid pioneer made his missionary trips across the deserts of southern Arizona.

This great house is the most important ruin of its type in the Southwest, and as such has strong claims for archeological study, repair, and permanent preservation. It has a peculiar fascination for the archeologist on account of its age and also because of the incompleteness of our knowledge of the ancient inhabitants of the Gila Valley.

The main building and its surrounding mounds, when considered together, may be called the Casa Grande group of ruins. Very little

[1] This paper is a report of progress on certain unfinished archeological work conducted by the author under a special appropriation for the exploration, repair, and protection of the Casa Grande ruins in Arizona. This appropriation was disbursed under the auspices of the Smithsonian Institution, and the field work extended from October 24, 1906, to March 24, 1907. Provision has been made by Congress for the continuation of the work during the fiscal year 1907-08, and it is anticipated that on completion of the exploration a final report will be published by the Bureau of American Ethnology.

attention had been paid to the mounds, and little was known of their contents and their relation to the main building up to the inception of this work. The mounds are arranged in several groups or clusters, that for reasons which it is hoped may appear sufficiently good are called "compounds." To distinguish it from other groups of the same type, the cluster chosen especially for excavation in 1906-07 is called Compound A.

The appropriation for 1906-07 sufficed to open the mounds and to remove the accumulated earth from about three-fifths of Compound A. In the course of this work there was found a wall which surrounds not only Casa Grande but also forty-three large rooms forming several clusters, some of which are larger than the historic Great House of Father Kino.[1]

The newly discovered walls have been repaired and protected from future harm, so that the visitor may now have some idea of the original appearance of the compound. The débris that had accumulated for centuries about the walls has been removed to a considerable distance, and they now stand out in bolder relief than they did when the Spanish padres first saw them. Where six months ago were mounds now rise houses with walls, floors, and doorways through which the visitor can walk, as did the ancient people before the place was deserted.

The removal of earth that had accumulated in the rooms and plazas from the surface down to the floor was in itself no small task, but this was only one phase of the work accomplished in making Casa Grande an "exhibition ruin." For the first time in the history of archeological excavations in our Southwest, an effort was made to repair and protect the walls that were uncovered, so that they should not suffer from the elements. As the walls of the houses are constructed of material which is easily eroded, their permanent preservation necessitated drains for carrying off the water, lest it penetrate the foundations and cause disintegration. The bases of all the walls excavated were treated with cement laid on an inclined plane of clay, forming a watershed by which the rain is deflected from the walls into small drains opening into a large ditch at the northeast corner, which ultimately conducts the water to a distant depression. About three-fourths of a mile of wall was given this basal protection.

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[1] This wall is figured by Font and Bandelier, but is not recognized as such by Cosmos Mindeleff.

Before the excavations were begun, the old stage road from Florence to the Casa Grande station on the Southern Pacific Railroad entered Compound A east of the main building, crossing it diagonally between the ruin and the two fragments of walls forming the southwest corner of the compound. The opening of rooms directly beneath this road made it necessary to divert it around the south end of the compound. The road-making incidental to this change in the highway necessitated grading and leveling in that vicinity. The level area thus formed would be a good place on which to construct one of the old circular huts of the Pimas, in order to show the character of the dwellings of the common people in prehistoric times.

As work progressed in this cluster of mounds it became evident that with proper treatment Compound A could be made a type ruin, representing many others scattered throughout the valley of the Gila and its tributaries. With this idea, therefore, the work at Casa Grande has been carried on—the idea of restoring for posterity a representative prehistoric settlement of the deserts of southern Arizona.

It is hoped that the plan of developing type ruins to illustrate culture areas of the Southwest may be carried out also in the Little Colorado, Rio Grande, and other river valleys of Arizona and New Mexico. Representative ruins, properly excavated, repaired, and protected, will greatly increase the interest of tourists as well as scientific students in the antiquities of our country. Needless to say, this plan would merit the support of the settlements near which the ruins lie.

The main objects of the work at Casa Grande are to bring to light rooms and walls, to repair and protect them, and incidentally to make a collection of objects for the National Museum.

Classification of Casa Grande Mounds

The artificial mounds at Casa Grande may be grouped into five classes, distinguished as follows:

1. Multiple or single mounds scattered over a rectangular area surrounded by a defensive wall. These enclosed areas may be designated *compounds*.

2. Single mounds covering buildings, but not surrounded by a wall. These may be called *clan houses*.

3. Oval mounds, ordinarily called "hollow" on account of central depressions, the bottoms of which are generally lower than the level

of the surrounding plain. These mounds, of which there is only one at Casa Grande, are supposed to be communal wells.

4. Mounds made up of refuse, sometimes sparsely covered with fragments of pottery. This type of mound passes without structural differences into the last class.

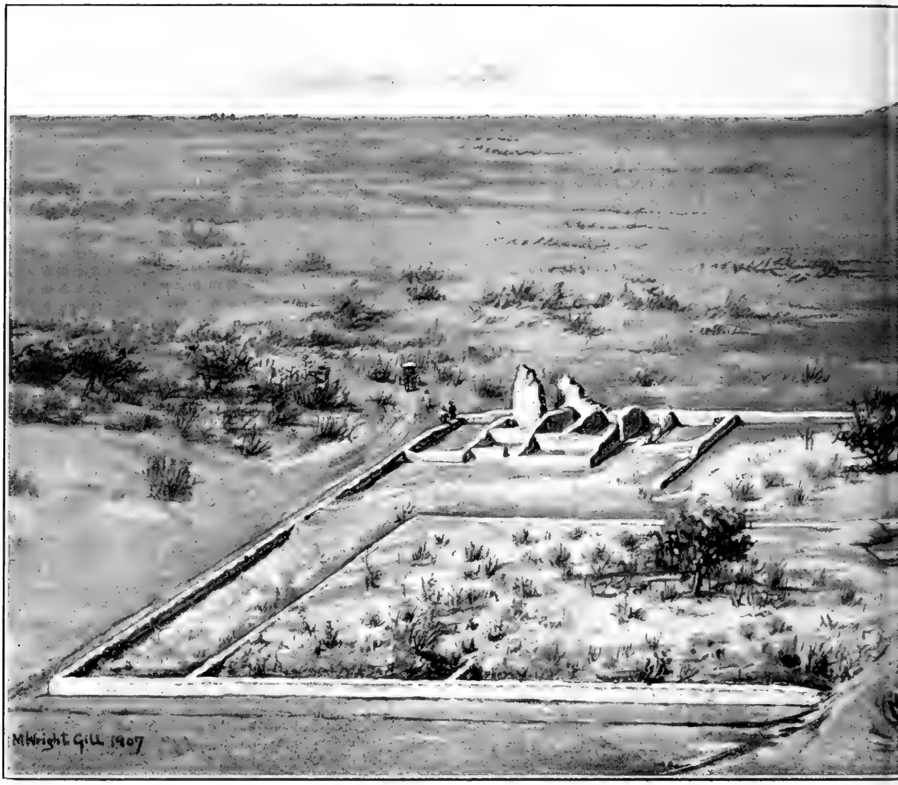
5. Earth mounds or chance accumulations of earth, without pottery fragments or other objects of human manufacture.

The first two classes of mounds under consideration are spoken of in the plural, as Great Houses (Casas Grandes) by many of the early visitors. For instance, Mange, a military officer who accompanied Kino, after having mentioned these Great Houses, says of one of them: "One of the houses is a great building." This he proceeds to describe so graphically that there can be no doubt that he has in mind the building we now call Casa Grande.[1] There were evidently other great houses standing near it when Mange visited the place, as he speaks of twelve other buildings in sight of the main house. The name Casa Grande is now applied to but one building, while the name "Casa Grande group" refers to the whole cluster of houses which were known to early writers as the "Casas Grandes of the Gila."

The mounds of the first two of these classes which were excavated were formed by ruined houses covered with débris so great in quantity that the walls were almost completely concealed, although in the latter part of the seventeenth century, when Casa Grande was first visited, both the surrounding walls and enclosed rooms were plainly visible. When the work here described began nothing could be seen but the rooms of the main building and three fragments of walls projecting above the ground (plates XXIII, XXIV).

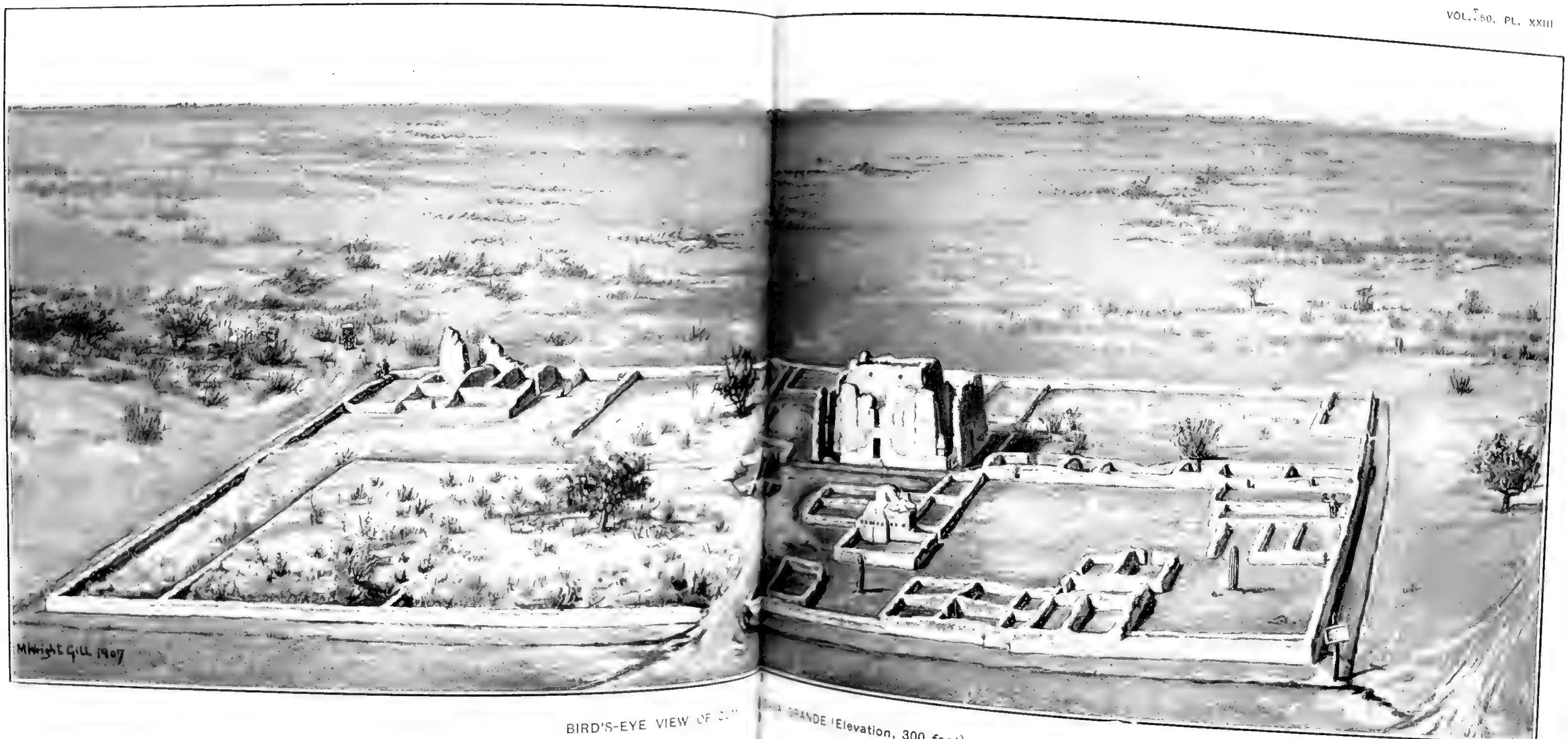
It is difficult to determine exactly the source of the great quantity of débris forming the mounds that conceal the walls of the prehistoric buildings of the Gila Valley. This material is largely adobe mixed with small pebbles, forming a grout like that of which the walls themselves are constructed, and probably consists of fallen

[1] Between the visits of the discoverer, Father Kino, in 1694, and Major Emory, the first American to describe them, in 1847, there was considerable change in the general appearance of the Casas Grandes of the Gila. The falling in of walls and the consequent filling up of rooms progressed rapidly after once the walls began to crumble. There has been little change in the skyline of Casa Grande since 1847, judging from Stanley's excellent view of the south wall, reproduced in Emory's Report, but sections of the east and south wall fell when the building was repaired a few years ago, considerably altering the appearance of the eastern side.



BIRD'S-EYE VIEW OF COMPO

RANDE (Elevation, 300 feet)



BIRD'S-EYE VIEW OF CASA GRANDE (Elevation, 300 feet)

roofs, drift sand, and other accumulations. In places the former height of the walls has undoubtedly been reduced several feet by portions falling down, and the earth about their foundations has gradually been raised to a level with their tops.

Some excavations were made in mounds of the fourth and fifth classes to determine their structure, but most of the time was devoted to the most important, or those containing rooms, as this seemed the best use to make of an appropriation allotted for excavation, preservation, and repair of the ruin. The work was largely devoted to one of the first class.

COMPOUNDS

The first class of mounds, consisting of those called compounds, is the most important of the above-mentioned divisions of mounds in the Casa Grande group, and is typical of the Gila Valley. Since the word compound[1] is here formally introduced to archeologists as the name of a new type of prehistoric structures of the Southwest, it may be well to dwell in detail on some of the salient features of the structure thus designated.

The compound is the characteristic structure of the Gila and Salt River valleys, as the pueblo is the type of the Little Colorado and Rio Grande drainage areas. The name is applied to a rectangular area bounded by a wall enclosing rooms, some of which are joined to the surrounding wall, while others are independent of it. A compound recalls Mexican rather than Puebloan architecture, although it has features in common with the latter. The compound was something more than a building for habitation; it was a gathering place for a much larger population than could be domiciled within it, and was apparently for assemblages both sacred and secular, for ceremonies, trade, protection from foes, and storage of food. The enclosed houses are comparable to composite kivas or ceremonial rooms. While the shape of a compound is, approximately, rectangular, it is not perfectly so, as no two sides have the same length and no angles are right angles; nor is the ground plan of any room exactly rectangular. This imperfection is believed not to have been a matter of design, but rather the result of a lack of instruments for precise measurement. A compound shows a preconceived plan of construction in contrast with a pueblo, to which additions were made as necessity required. Its ultimate form was apparently thought out

[1] From the Malay *kampong,* according to the Standard Dictionary.

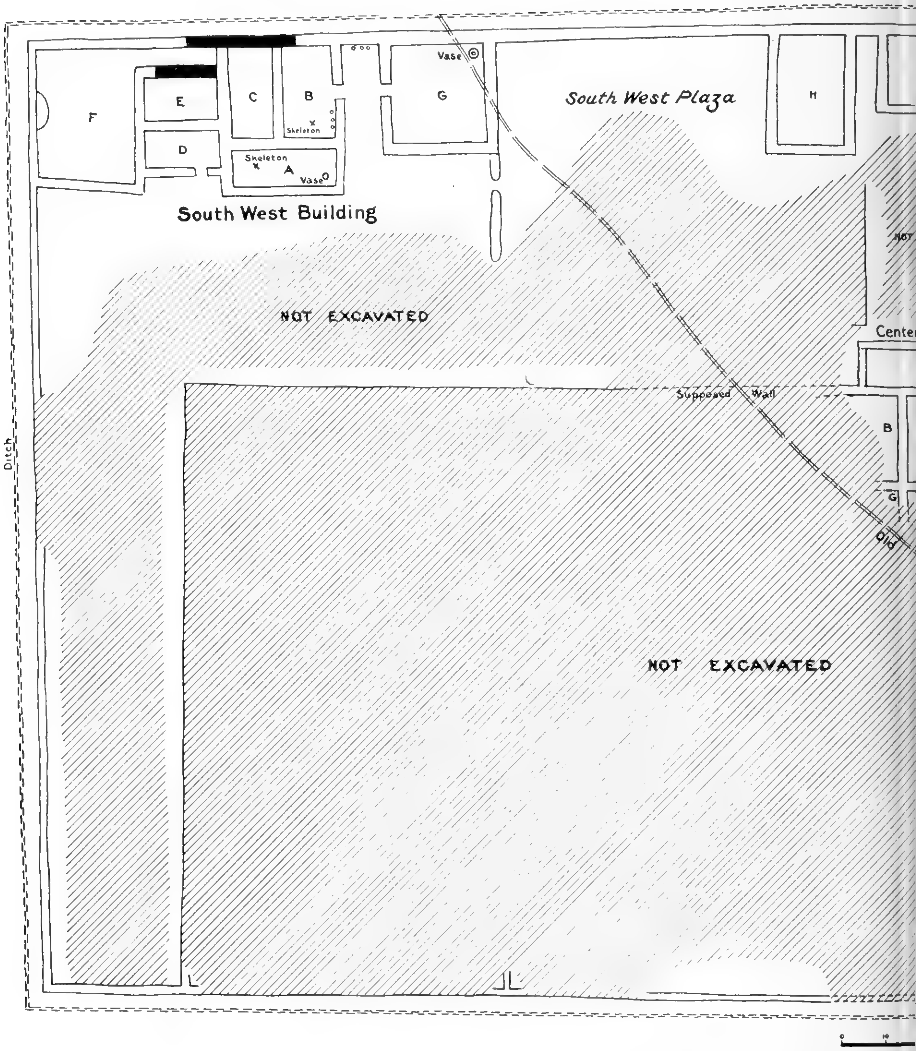
before the bounding walls were constructed. The compounds are simple architecturally and their construction is rude. They do not show the daring in building exhibited in cliff houses, nor the skill displayed in pueblos built on the edges of precipices. They give no evidence of any great skill in masonry or in overcoming difficulties of construction. This compound type of architecture is represented by many examples in the Gila drainage region, and may or may not be associated with other classes of mounds. It is only rarely that the type is duplicated in the same cluster, as at Casa Grande.

1. COMPOUND A

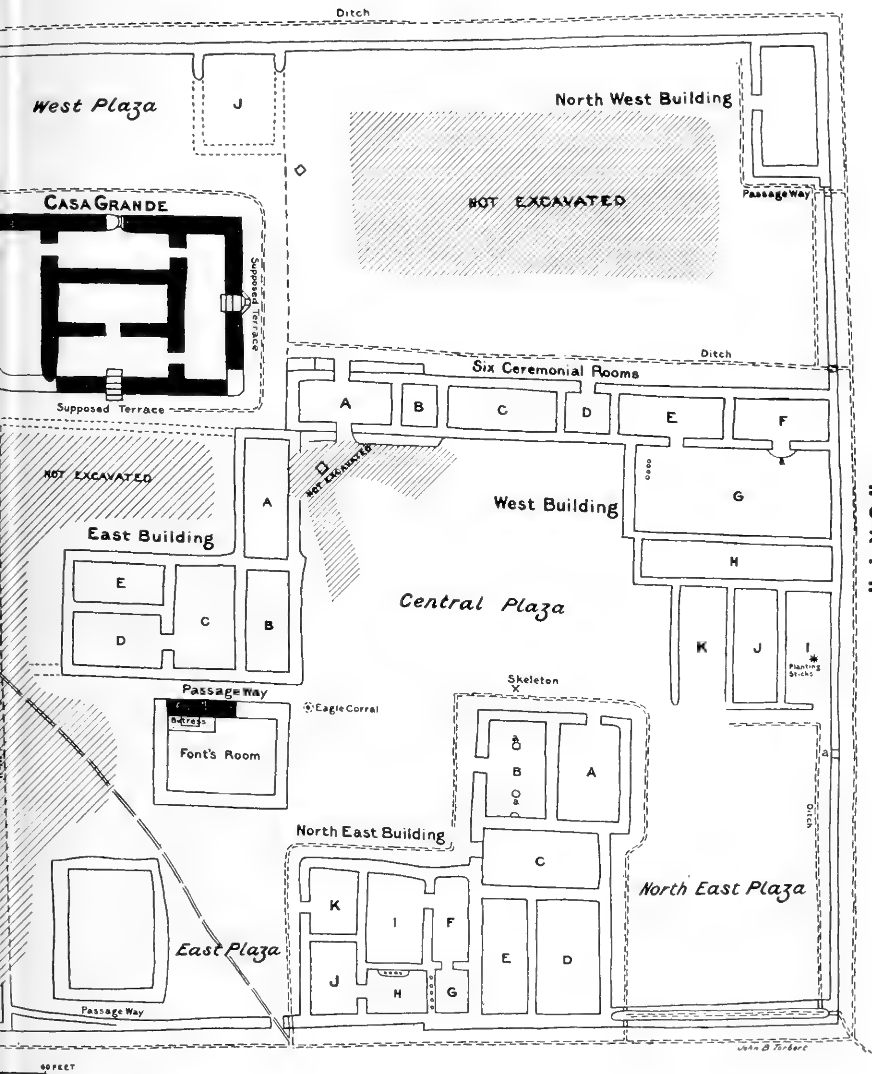
Two or possibly three compounds have been recognized in the Casa Grande group, and of these Compound A is the largest, although it contains no building equal in size to the main house of Compound B. Compound A is believed to have been the last of the three compounds to be deserted by its inhabitants, for it is the only one with fragments of walls standing above ground. The longest side of Compound A is oriented 3° east of the true north-south line.[1] The surrounding wall has been traced throughout and laid bare on both sides, without and within. Its former height varied a little at different points, having been greatest near attached rooms, where the wall is also greater in thickness. The bounding wall of this compound averages two feet in thickness, and was originally not far from six feet high.

In Kino's time, and as late as 1775, when Font visited the ruin, the surrounding wall and many enclosed buildings were probably in a fair state of preservation. The latter in some instances had roofs supported by rafters, and plastered walls which rose somewhat higher above the ground than at present. There is evidence that all sections of the outside wall of Compound A were not constructed at the same time, but that the structure was enlarged after a few generations. Considerable intervals of time may have elapsed between the erection of the six ceremonial rooms and the large walls east of the north room of this series. The outside wall of the compound shows evidences of having been successively extended, the oldest part being the western half, or that which contains the historic building, Casa Grande. The east wall of the six ceremonial rooms extends east of Casa Grande, and once formed a retaining wall about

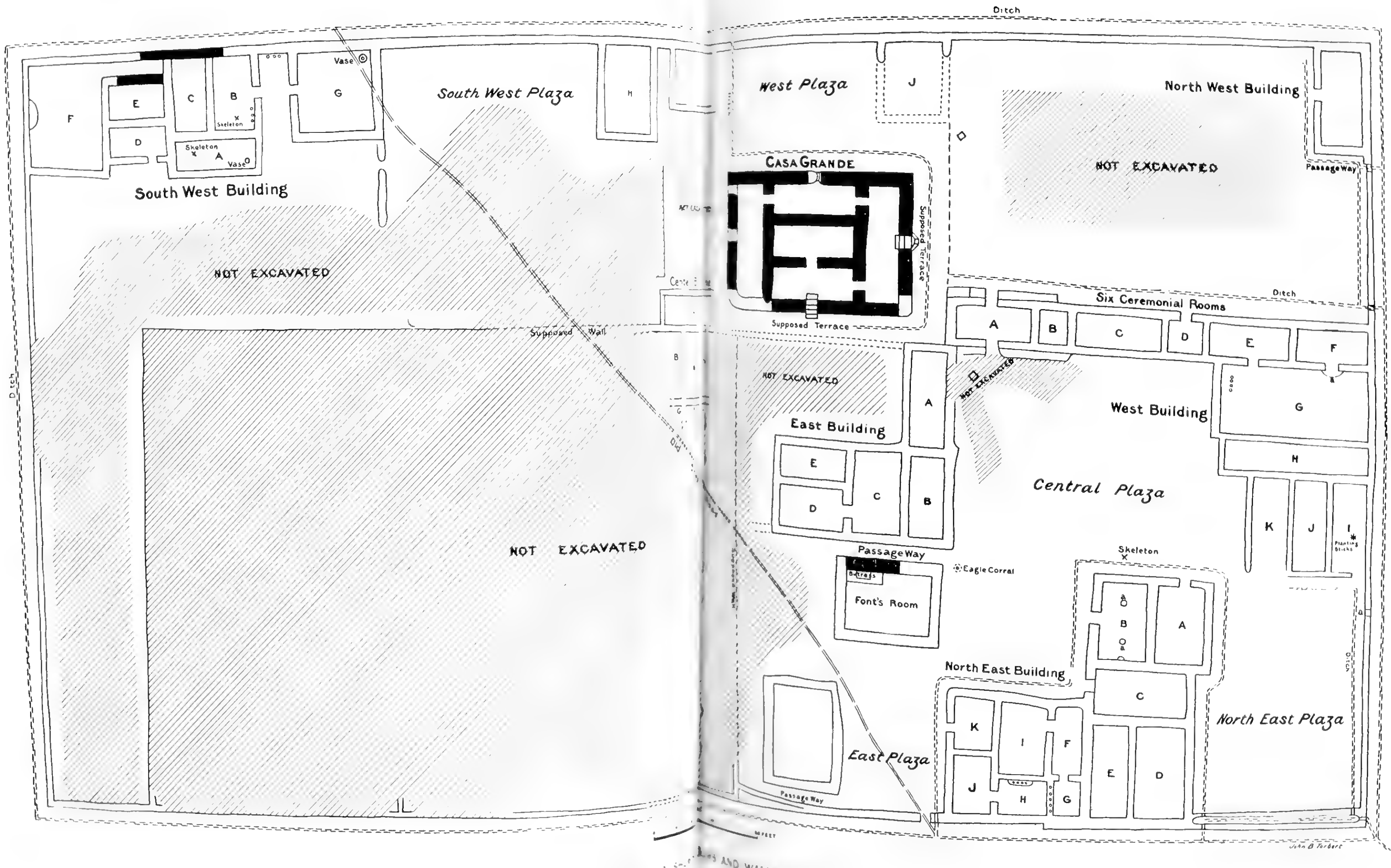
[1] The west wall of Casa Grande, however, is north 4° 30′ east. The south wall of the compound measures south 8° 35′ east.



GROUND PLAN OF COMPOUND A, SHO



D WALLS EXCAVATED IN 1907-8



GROUND PLAN OF COMPOUND A S[illegible] AND WALLS EXCAVATED IN 1907-8

eight feet from the main building. It extended southward, forming the main wall of the central building and the east wall of the southwest plaza. This extension of the ceremonial rooms may once have been the east wall of a narrow compound containing the main building and the cluster at the northwest angle of the original compound. On this hypothesis the rooms east of Casa Grande may have been additions, the buildings of the northeast, central, and east plazas not having been included formerly within the walls that surrounded the main building.

It appears from the author's explorations that the main building does not stand in the middle of Compound A, but is nearer the west and south sides than the east and north. The most important buildings of the present enclosure are situated on the east, north, and south sides of Casa Grande, those on the west being small and inconspicuous. This arrangement was evidently intentional, primarily heliotropic, that is, for the purpose of allowing outlooks from roofs to the east for sun worship or other ceremonial purposes.[1]

The main building was not isolated from the others, but connected with them at its base on the east, north, and south sides. The roofs of neighboring buildings communicated directly with a terrace on a level with the lower rooms of the main building, which opened upon the terrace through low, narrow entrances. By the use of ladders one could mount to the doorways of the second story of the main building, which were situated on the east, north, and south sides.

The south wall of Compound A is curved slightly outward, the curvature reaching its maximum at the point of union of the north wall of the six ceremonial rooms, where it is over two feet, or a little more than the width of the wall. The west wall is without curve from the northwest to the southwest corner, and is a fine specimen of aboriginal masonry constructed without instruments of precision. The south wall, which is a little more than half the length of the west wall, is likewise straight. This is also true of the east wall, which, however, is double at the northeast end, being broken by a small jog or reëntrant angle about a hundred feet from the northeast corner of the compound.[2]

The purpose of the double wall at the northeast angle of the compound is not known; perhaps it is connected in some way with the

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[1] The openings in Casa Grande through which the sun priest watched the rising and setting sun are still visible. Their use, as mentioned by early writers, will be discussed in a final report on the building and its purposes.

[2] A similar break in the wall is also found in the Casa Blanca compound.

jog, above mentioned, in the east wall opposite the northeast building. It may have been that the inner of the double walls was built first, and that, when finished, failing to please the builder, a new wall was constructed to replace it.

The height of the wall surrounding the compound can only be conjectured, but from the amount of débris six feet would be a conservative estimate. Of course, when any part of the surrounding wall formed the wall of a building, its height was greater, rising near the southwest angle to over 20 feet. The width of the wall also varied in different places, being, as a rule, greatest where it served for walls of enclosed buildings. At points where the component blocks of this wall are clearly to be seen they are identical with those of the main building. The walls of the enclosed rooms were also constructed in the same way as those of Casa Grande—of huge blocks of grout, the outlines of which are still visible. It is not wholly clear, however, that they were made in movable frames, as is generally believed, but rather laid in courses, the lines of separation representing periods of labor. As in the main ruin, the prints of human hands and fingers can be seen on component lumps of *"caliche,"* as if they were patted into shape after the lumps were laid on the walls. Each of these component lumps of clay was a good basket load for transportation on a man or woman's back. The walls are sometimes strengthened with upright logs, and in a few cases the base of the wall is increased in thickness, as shown in plate XXXV, *b*.

The outside surface of the buildings seems to have been originally smooth, perhaps plastered, but was generally found to be so eroded that the superficial covering had been worn away. In a few places the warm orange-red color of the historic structure was detected on the newly exposed walls.[1] The inner surface of most of the walls of the buildings is blackened by smoke, while the beams of the floor or roof are generally reduced to charcoal. This black mural discoloration is laminated, showing that the rooms were freshly plastered from time to time. Green paint appears on some of the walls, but no drawings or figures are visible. There are hand and finger prints in the clay of which the walls were made, but they are very indistinct. Most of the corners of the rooms are not bonded, and there are cracks wide enough to admit the hand be-

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[1] It cannot be denied that the outer wall of the historic building, Casa Grande, has a marked reddish color on its surface; but whether this color resulted from paint or oxidation is as yet undetermined. The color of Casa Grande is not white, as some have stated, but red.

tween the end of one wall and the face of another upon which it abuts. This failure of union is due to the method of construction of the walls themselves, for they evidently were not carried up at the same rate on all sides. In some instances these cracks were visible on the surface of the mound before excavation began, indicating the corners before the rooms were opened. While the majority of rooms in the enclosure adjoin the surrounding wall, so that it serves as one or more sides, there are two rooms that are free on all sides from any connection of this kind. These independent buildings are separated from others by courts or plazas. The most conspicuous of these is a room, formerly two stories high, called after the zealous priest, Father Font, who first gave its dimensions and correctly mapped its location in respect to the main building (plate XXIII).

Relic-hunters have dug into several large mounds of the compound and left their marks on some of the best walls. This mutilation is particularly noticeable in some of the rooms of the northeast cluster, especially the northeast corner room, where much of the wall had been practically destroyed before the author began his excavations. Necessary repairs were made, however, and what remains of the wall is protected from harm for the present.

BUILDINGS

The following buildings, plazas, and courts were excavated in Compound A:

(1) Southwest building; (2) northeast building; (3) rooms on west wall; (4) six ceremonial rooms; (5) central building; (6) Font's room; (7) rooms between Casa Grande and Font's room; (8) rooms adjoining ceremonial rooms on north wall; (9) northwest room; (10) room near east wall; (11) northeast plaza; (12) central plaza; (13) east plaza; (14) southwest plaza; (15) south court.

These house groups and plazas shown in the accompanying bird's-eye view and ground plan (plates XXIII and XXIV), in which the unopened part, buildings and plazas, bear appropriate legends, will be considered in the order given above. Of the 43 new rooms considered, the majority were excavated to the floor, and in several the excavations went to a greater depth, where many of the best objects were obtained. The existence of a majority of the buildings was recognized superficially by mounds or small elevations, but the course of the walls generally had to be traced by following their connection with other walls already discovered and excavated.[1]

1. Southwest Building

Father Font wrote of Casa Grande as follows: "The house Casa Grande forms an oblong square facing to the four cardinal points, east, west, north, and south, and round about it there are ruins indicating a fence or wall, which surrounded the house and other buildings particularly in the corners, where it appears there has been some edifice like an interior castle or watch-tower, for in the angle

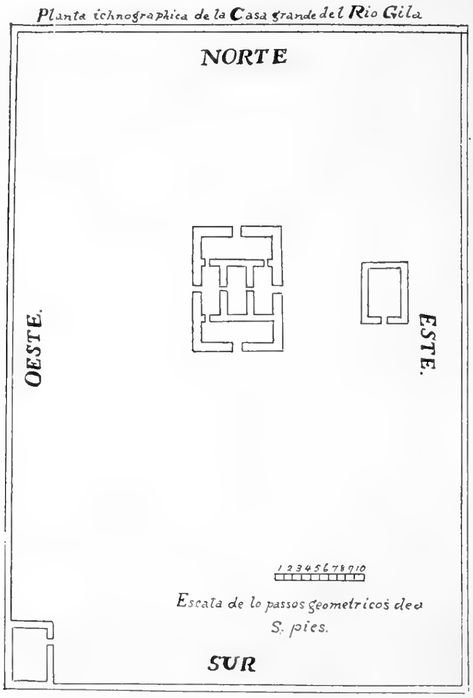

Fig. 117.—Font's ground plan of Casa Grande

which faces towards the southwest there stands a ruin with its divisions and an upper story." This southwest building is undoubtedly one of the "other buildings" above referred to.

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[1] It will be noticed that none of the walls of the main building are exactly parallel to those of the compound, and that its plan is different from that of any other house in the area enclosed.

a View from southwest before complete excavation

b View from northeast before complete excavation

SOUTHWEST BUILDING

a View from northeast

b View from north

SOUTHWEST BUILDING

In Font's plan (figure 117) of Compound A, a single chambered room is represented in the southwest corner. Bartlett gave a ground plan of the cluster of rooms in this angle, but neither Bartlett's nor Font's plans are complete, for there are in reality six rooms in this corner of the compound, not counting an adjacent rectangular room separated from this cluster by a court. Several later authors have mentioned and figured these two fragments of walls standing above a mound southwest of the main building, and one or two have suggested that they were formerly connected with Casa Grande by walls. The best view of these pinnacles appeared in Cosmos Mindeleff's valuable account[1] of the ruin.

The author's excavations of Compound A were begun at the base of the more western of these two standing walls, at the level of the ground, where it was found that the wall was so eroded as to be seriously undermined. It was recognized that extensive filling in was necessary at that point, and that other repairs were imperative to keep this fragment from falling. The fragment east of the last mentioned was, if anything, in a worse condition, and also required protection.

Digging down below the eroded portion, there came into view a fine smooth-faced wall, which extended several feet still lower. The excavations were then continued north and south, following the face of the wall to the northwest and southwest angles, laying bare the whole west wall (plate XXXIV, *a*). After having traced this wall, attention was directed to the general character and arrangement of the walls hidden below the mound near the bases of the two fragments of walls where the excavation started. It was found that the southwest corner of the compound is occupied by a cluster of six rooms (plates XXV-XXVI), the most picturesque of all those uncovered during the winter.

2. Northeast Building

As may be seen from the ground plan (plate XXIV), the first historic building, Casa Grande, was not the largest in Compound A. The combined length of the six ceremonial rooms is double that of the main building, although their width is much less. A building standing northeast of Font's room is the largest yet excavated and contains many more rooms, some of which are larger than any in the historic building.

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[1] 13th Annual Report of the Bureau of Ethnology.

The arrangement of the rooms in the northeast building (plate XXVII, *a, b, c*) is different from that of Casa Grande,[1] but is typical of others, especially the extra-mural clan houses. This similarity would lead one to suspect that this building was not, like the main building, a ceremonial, but rather a residential house. The typical form, to which reference is made, is that of a carpenter's try-square, or that of two sides of a rectangle—a form that reappears in the most southernly situated of the two clan houses on the east and the cluster of rooms in the southwest corner of Compound B. The six ceremonial rooms, together with those extending eastward from the most northern of these along the inner surface of the north wall, make also a group of the same try-square shape. Since one arm of the northeast cluster is formed by the east wall of the compound, it follows that this arm extends approximately east and west, and necessarily the other arm of the try-square lies at right angles, or north and south.[2]

There are five rooms in the east-west arm of the northeast cluster (plate XXIV), two at each end, separated by a single room. All of these rooms have comparatively massive walls, and in most the superficial covering, or plastering, is fairly well preserved.

Room A, at the west end of the eastern arm of this try-square, had been partially excavated before the Government began work at Casa Grande, but was left in such a bad condition that parts of the east and south walls were practically destroyed. The author repaired them, filling in the badly eroded holes and walls with adobe bricks and restoring the wall as best he could to its original condition.

Room B is one of the best-preserved rooms of those excavated. It was opened down to the level of the floor, which was found to be hard and well plastered. Midway through the center of this room,[3] at equal distances from east and west walls, there are two holes, *a, a,* in the floor, in each of which was an erect log, charred by fire, but

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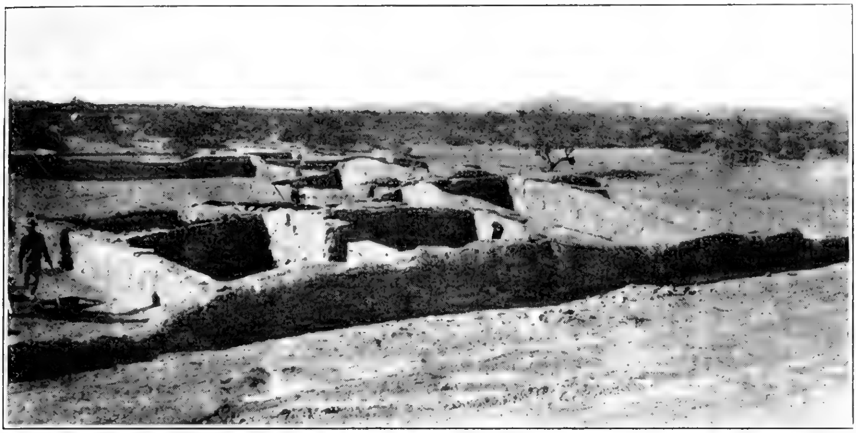
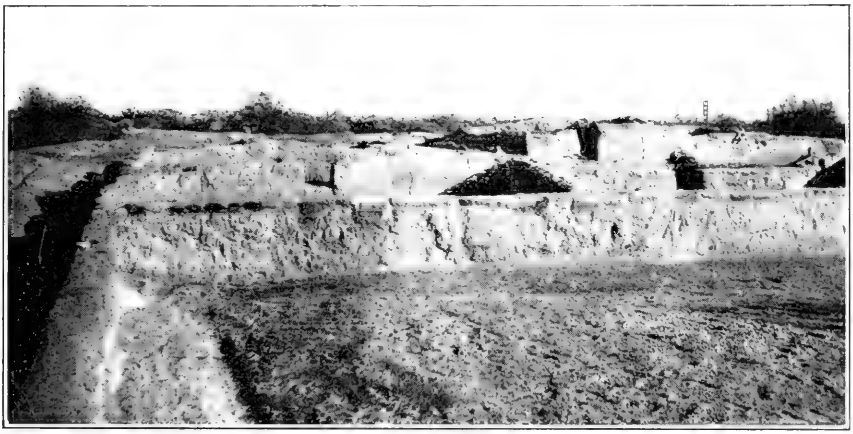
[1]No building in the compound has the same arrangement of rooms as Casa Grande. It will be instructive to see whether the pyramid of Compound B resembles Casa Grande in this particular.

[2]The theory that the historic Casa Grande is composed of two of these try-square-formed buildings, constructed at different times and united, is not wholly evident, nor is it clear that certain rooms, as the northern, have been added to this building since the others were built.

[3]The arrangement of rafters in this roof recalls that of a Pima round house.



a View from southeast, outside compound

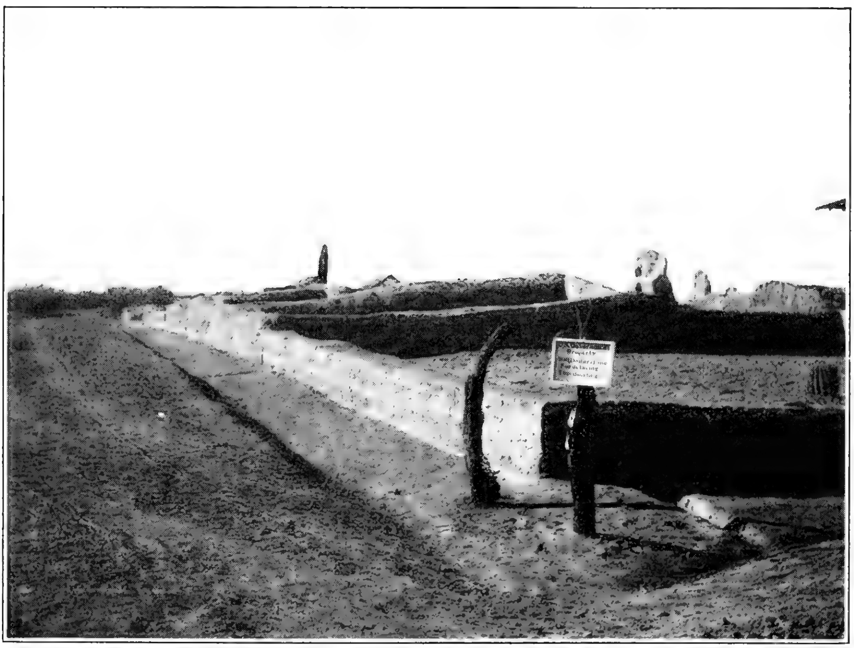


b View from northwest plaza

c View from outside north wall

NORTHEAST BUILDING

a Northeast angle and plaza



b East wall

COMPOUND A

still standing erect. These vertical logs once supported a horizontal rafter extending from the east to the west wall, resting on both and on the vertical supports. Side rafters were supported by this middle log, with ends resting on the north and south walls. Upon these smaller rafters was the roof covering of reeds and clay.

The other three rooms, C, D, E, of the east-west arm of the northeast building, were excavated to their floors. Their walls were found to have good surface finish, "as fine as Puebla pottery," and in one instance, D, showed superficial painting. These rooms, D and E, have no lateral doorways, a significant fact, which strengthens the belief that their former entrances were hatchways on the roof. None of the above-mentioned rooms open into one another. Large stones were found to have been used in the construction of the foundations of the north wall of room D.

The rooms of the east section (plate XXIV) vary in size, and apparently some had lateral doors, others hatchways. The narrow wall of the small room, G, was supported by upright logs. A section of the fallen roof was laid bare in room H, in which the rafters and the clay upon them were well preserved. Apparently the rafters in this room had simply fallen against a side wall, the ends that formerly rested on the east wall having decayed.[1]

The walls of rooms J and K show plainly the action of fire, for large quantities of charcoal filled these rooms. G has a good floor and fine surface finish on the walls. The partitions between these rooms are, however, much broken down. In view of their supposed domiciliary character, it is interesting to point out the absence from these rooms of domestic utensils.

3. Rooms on the West Wall

Between the cluster of rooms occupying the southwest angle of the compound and the single "bastion" or "castle" at the northwest corner, there are several rooms, the walls of which appeared when the soil was removed from the inner or east side of the west wall.

The most characteristic of these dependent rooms, G, is separated by a narrow court from the northern wall of the southwest cluster. Unfortunately, one corner of this room was cut down before its existence was detected, but wherever its four walls were revealed

[1] No hatchways or roof entrances had previously been reported from prehistoric houses in the Gila drainage.

they indicated a room of large size.[1] In one corner there stood a large vase, too fragile to remove, which was consequently left in the place where found. The Casa Grand-Florence stage route formerly crossed the compound over the corner of this room directly above this vase.

On the west side of Casa Grande, or directly between the main building and the west wall of the compound, there were excavated several rooms, H, I, and J, the walls of which are low and single-storied. One of these rooms, J, is situated on the northwest corner of the ruin, and has its west wall continuous with that which forms the retaining wall of the north terrace. There are also two rooms on the southwestern corner which bear the same relation to the terrace wall of the south side. These two are separated by a court[2] and have low walls. There does not seem to have been a building directly west of the main ruin and no sign of a terrace now remains on that side.[3] The exact connections of the rooms along the west wall, southwest of the main ruin, with those on the southwest corner can be made clear only by continuation of the work in the unexcavated part of the compound. As shown in the ground plan (plate XXIV), there are walls standing in that part of the compound; there is also a level space called the southwest plaza, situated between the wall of the most southern room at the southwest angle of the main ruin, and the northern wall of the room on the west wall adjacent to the building in the southwest angle.

4. Six Ceremonial Rooms

Linear arrangement of rooms is exceptional in this compound. This row extends from the northeast corner of the main building to the north wall of the compound, with which the most northern room is united. The line of these rooms is not parallel with either the east or west walls of the compound, and their longest measurements vary, although the widths of the rooms are about uniform. Although the connection which formerly bound these rooms to the main building has been destroyed, there is no doubt that such a union once ex-

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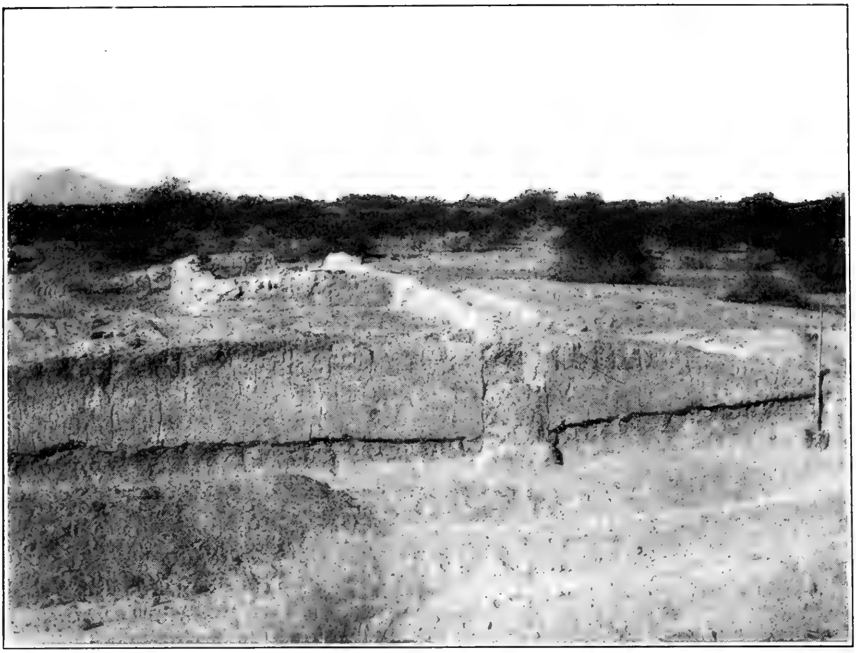
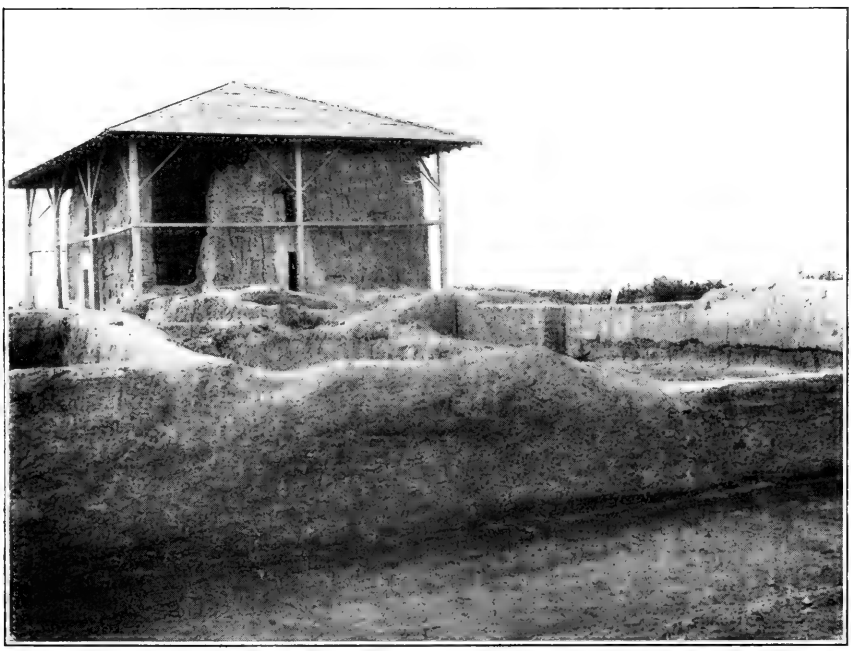
[1] It is often difficult to follow the walls of these buildings, because they are so soft, but on exposure to the air they harden very much.

[2] There are several instances where walls of adjoining rooms are separated by blind courts. As there were no openings from the rooms into these courts, the reason for their existence is problematical.

[3] Most of the exterior openings of the west room of Casa Grande were filled before the building was abandoned.

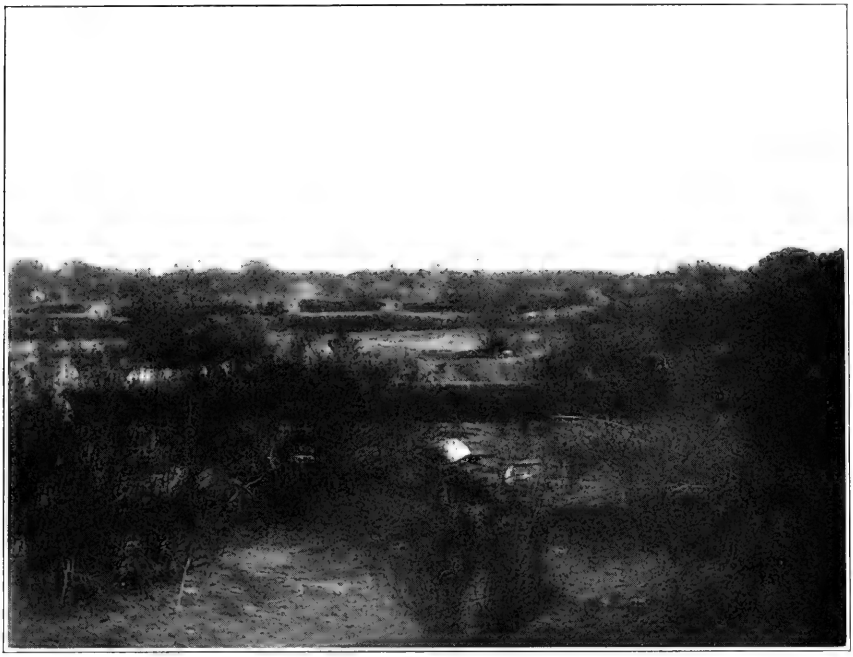


a View of east wall showing basal erosion

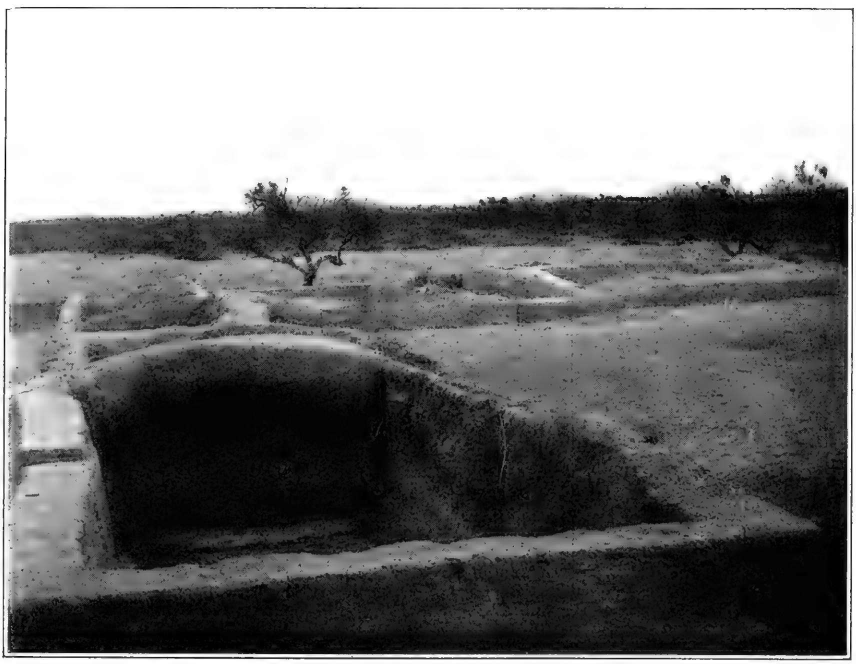


b View of north room from outside compound

NORTH ROOMS



a View from outside west wall of compound



b View from north room of Casa Grande

SIX CEREMONIAL ROOMS

a View from six ceremonial rooms

b View from northwest

NORTHEAST BUILDING

isted, and that they were probably united to a solid terrace which we must suppose existed on the north, east, and south sides of the main building.

Before excavations were begun, the row of ceremonial rooms was indicated only by a ridge[1] of earth extending from the northeast corner of the main building northward. It is evident that the roof of these rooms was on a level with the floor of the lowest rooms of Casa Grande,[2] which communicated with the roofs of these ceremonial rooms on the north, east, and south by means of the basal terrace, of which mention has been made. In this way one could pass directly into these rooms through the doorways in the middle of the sides of the main building.

The form, size, and general appearance of the walls of these six rooms are shown in the accompanying plan (plate XXIV) and in plate XXX, *a* and *b*. All these rooms were excavated to their floors, the soil from them being removed beyond the surrounding wall of the compound. Earth was likewise taken from the west side, opening the east portion of the northwest plaza, so that the walls on that side now average five feet in height.

5. Central Building

When work was begun on Compound A the central building was a low, regular mound[3] situated near the southeast angle of the main building, occupying a somewhat similar relation to that corner that the first of the six ceremonial rooms does to the northeast angle. This mound was opened to the base, revealing several intersecting walls and rooms (plate XXIV). When one stands at the north wall of the compound and runs his eye along the east side of the six ceremonial rooms, it is found that the middle wall of the central building is in the line of the eye, which also follows the supposititious retaining wall of the east terrace of the main building and the east

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[1] This was a favorite camping place of visitors, being in the shade of the old building.

[2] It is much to be regretted that the union of the buildings around Casa Grande and the main house was cut away by contractors without tracing these connections, for it is now impossible to find out the exact relationship.

[3] When Casa Grande was first repaired the section of wall forming the east end of the south room fell to the ground near this mound. This unfortunate accident was the first radical change in the outer walls of the building since 1847. The author removed the fallen material and placed it in the south room, which had been excavated too deep below its floor.

boundary wall of the southwest plaza. The southeast corner of the main building, Casa Grande, is broken in much the same way as the northeast angle near the six ceremonial rooms, possibly from the same cause.

6. Font's Room

Mange states that Father Kino said mass in the Casas Grandes, and it is generally believed that this ceremony was performed in one of the rooms of Casa Grande. As there were at the time of Kino's visit several other rooms in the group, some of which were more commodious, it is interesting to speculate on the possibility of one of these being that referred to.

Just east of Casa Grande was a large building (plate XXIV), formerly two stories high, which was apparently in a fair state of preservation when Father Font visited it in 1775. So accurately has this zealous priest described[1] and mapped this room, that it is called after him and is referred to as "Font's room," in this article.

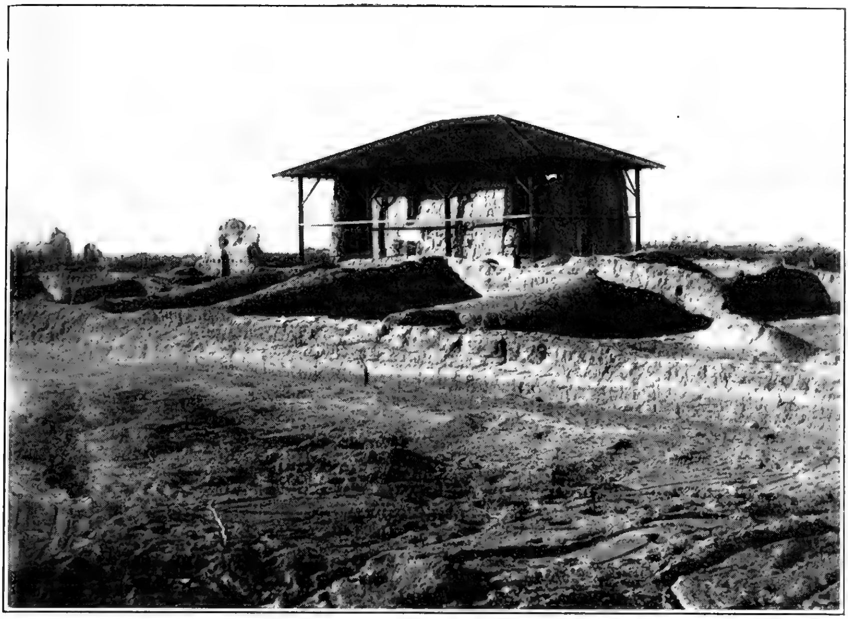
Mange states in his diary that "a crossbow-shot farther on, twelve other houses are seen half tumbled down, also with thick walls and all with roofs burnt except one room beneath one house, with round beams smooth and not thick, which appear to be cedar or savin and over them rush reeds very similar to them and a layer of mortar and hard clay, making a ceiling or story of very peculiar character."

Font, 70 years after, wrote: "In front of the east door, separated from the Casa, there is another building with dimensions from north to south 26 feet and from east to west 18, exclusive of the thickness of the walls."[2]

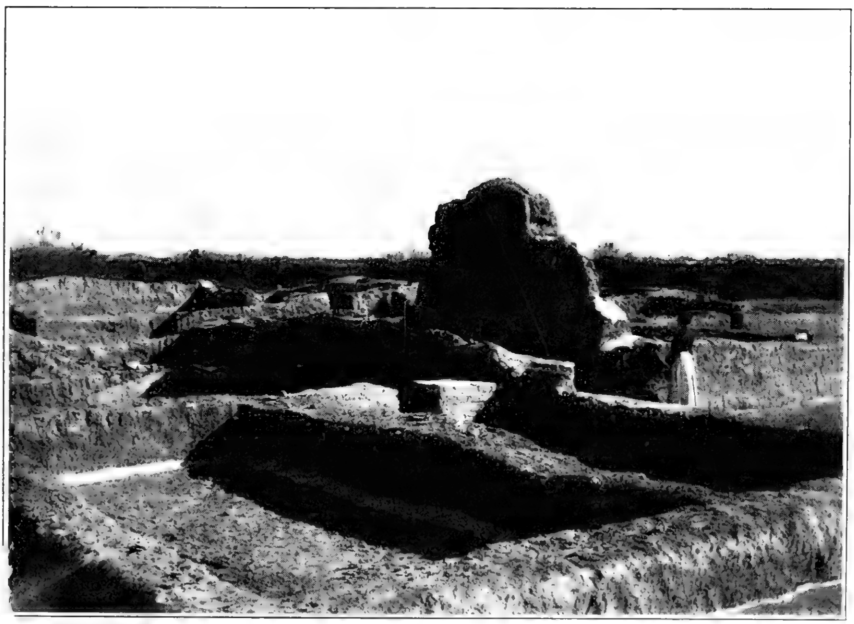
Although it was possible in 1694 for the observer, standing on the roof of Casa Grande, to see the walls of all the buildings which were excavated by the author, the best preserved of all, judging from Font's account, was that named after him. At that time this was apparently the only two-storied building in good preservation east of the main one, which could be designated as "one room beneath one house." The general appearance of this building last October (1906) is shown in the accompanying plate (XXXIV, *a*, *b*). The upright wall of this room was the only fragment besides the main

[1] Diario a Monterey por el Rio Colorado del Padre Pedro Font, 1777. Copy of the original manuscript, which is in the John Carter Brown Library, Providence, R. I., now in the archives of the Bureau of American Ethnology.

[2] Font's measurements correspond very closely to the dimensions of the room here referred to.



a View from outside east wall



b Rooms between Casa Grande and passageway west of Font's room

NORTHEAST BUILDING AND EAST ROOMS

building above ground, with exception of the two walls at the southwest angle. The condition of the base of this wall necessitated immediate repair; for, although three feet thick, it was so undermined that light was visible through holes in the base. The author erected on its east side a buttress of adobe bricks to strengthen it, and took other precautionary measures to keep what was left from falling. The row of holes in which were formerly inserted the ends of the rafters of the upper chamber can still be seen in the east face of the wall.

Directly west of Font's room is a passageway communicating with the central plaza. The floor of this passageway is hard and very compact, and on one side there were excavated an eagle skeleton and bones of several rabbits.

7. Rooms between Casa Grande and Font's Room

East of Casa Grande there were several large rooms, A-E (plate XXXII, *b*), with low massive walls, evidently of one story. It would appear that in ancient times these rooms joined the terrace at the base of Casa Grande, and we may suppose that their roofs were on the level with the floor of the lowest room of the historic building. Apparently these rooms were not all constructed at the same time, the two at the north showing evidences of being older than the southern pair.[1]

One of these rooms, C, was found to contain much débris, consisting of pottery fragments, charred basketry, cloth, maize, mesquite beans,[2] marine shells, and other objects. It appears to have been a dumping place, and, as it has every appearance of having once been a room, we may suppose that it was deserted while some of the other rooms of Compound A were still inhabited.

8. Rooms Adjoining the Most Northern of the Six Ceremonial Rooms

Adjoining the most northern of the six ceremonial rooms on its east side, there lies a room, or court, G, surrounded by walls, which appears to have been without a roof (plate XXIX, *a*, *b*). Its floor is

[1] This conclusion was arrived at by study of the connection of the walls, the northern or more recent having been built into eroded portions of the older.

[2] Flour cakes made of ground mesquite beans was a favorite food of the Pimas. Alarcon, in 1542, was given loaves of "mezquiqui (probably mesquite meal) by the California tribes.

hard, as if made so by the tramp of many feet; its walls are massive, with smooth surfaces. A walled-up doorway, recalling a similar feature in the west room of the main building, occurs in the wall separating this room from the most northern of the six ceremonial rooms.

In the surface of the west wall of this room, at the level of the floor, there is a deep erosion of the wall, shown in plate XXIX, due to former weathering. The south wall of this enclosure was evidently built since the erosion took place, for its end is so constructed that it extends into the eroded region, following the imperfection in the surface without being itself weathered at that level.

The five rooms, G-K, forming the west building are large and have massive walls. No evidences of roofs occur, and lateral doorways are absent except in the east side of I. K shows evidence of an east wall, and the narrow enclosure H is more of a court than a room. A pile of wooden hoes or planting sticks (plate XXXIX, *g*) was found on the floor of room I.

9. Northwest Room

The dimensions of the room occupying the northwest angle of Compound A appear in the accompanying plan (plate XXXIV, *b*). This room is single-storied, with free walls on two sides, the other sides being the walls of the compound. An entrance into the compound on the north side is situated near this corner room.

The excavations revealed many ceremonial objects on the floor, which would appear to indicate that the room was used for other than secular purposes. Household utensils, as grinding-stones, which would be expected in a living chamber, were absent. No soot or other evidences of a fire were observed on the walls, and there were no charred logs or rafters.

10. Rooms near East Wall

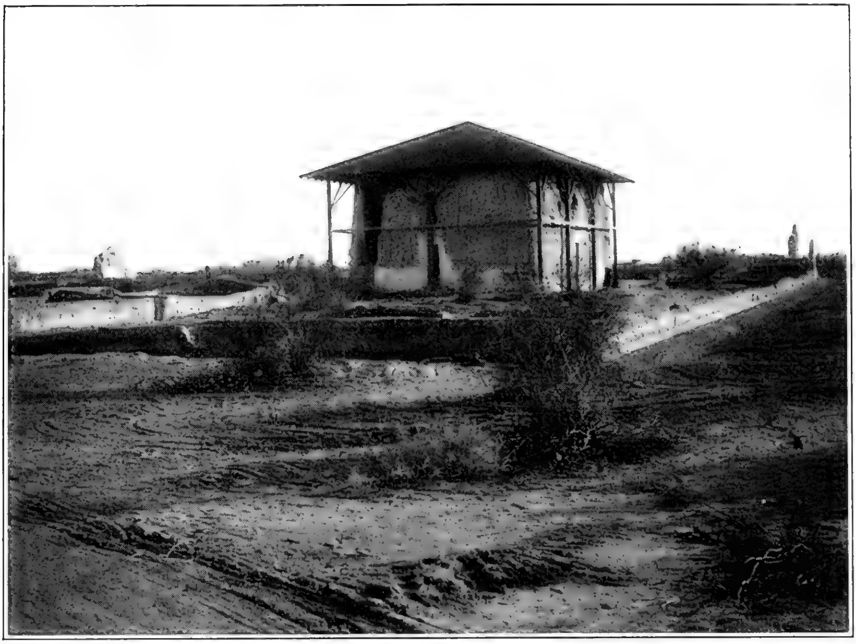
South of the plaza which lies to the eastward of the two-storied building known as Font's room, are situated the remains of some massive walls which formed a large square enclosure separated from the east wall only by a narrow passage.[1]

[1] The old stage road from Florence to Casa Grande took advantage of a low place in the east wall for its entrance to the compound. The author suspected the presence of a doorway at this point, but did not find it. The east wall was unbroken by any openings.

a View before excavation

b View from same point after excavation

WALL OF FONT'S ROOM ABOVE GROUND BEFORE EXCAVATION, FROM NORTHEAST



a View of west wall from northwest

b View of northwest room from northwest

This building was evidently formerly one story high. Its size is so great that it is doubtful whether or not it was roofed, but if it had a roof it would be one of the largest rooms of Compound A.

11. THE NORTHEAST PLAZA

The removal of earth to a depth necessary to show the original height of the walls about this plaza was a work of some magnitude, but was accomplished in a short time.[1] The plaza (plate XXVIII, *a*) was not apparent until after the position of the northeast angle of the compound had been determined and the walls of the northeast building had been excavated.

The situation of this plaza and the fact that no doorways opened into it or terraced roofs looked down upon it, implies that it was not a favorite one for ceremonial dances or spectacular performances. As the walls about it are, as a rule, massive, the plaza may have served as a safe place to which to fly for protection, and it is probable that cabins, not unlike the Pima huts of the last generation, were temporarily erected in this and other plazas.

12. CENTRAL PLAZA

The centrally placed, and on that account probably the most sacred, plaza (plate XXIV) of Compound A is surrounded by buildings, the roofs of which no doubt served as elevations from which spectators could witness the sacred dances and games. The floor of this plaza was solid, apparently hardened by constant tramping of feet. The labor involved in cutting down the earth in this plaza to the former floor was considerable, it being necessary to remove many cubic yards of grout that had fallen from the thick walls of the northeast building and the six ceremonial rooms. The southwest corner of the plaza was not excavated because of a large stake to which is attached the iron rod that serves as a guy for the northeast corner of the roof built over the ruin.

The plaza appears to have been used as a burial place, for a human skeleton was dug out of the floor near its southeast corner, but the body might have been buried after the compound had been deserted.

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[1] The author employed as laborers in this work Pima Indians from the village of Blackwater. He found them very efficient workers and universally honest in their work. It is believed that the $2,400 of the appropriation paid to them was of great material aid, and that the work stimulated their mentality and did much to intensify their self-respect.

There was excavated from this plaza, near the passageway west of the tall wall of Font's room, the skeleton of an eagle and several rabbit bones. It was probably customary at Casa Grande to domesticate eagles for their feathers and to keep them in confinement.

13. East Plaza

This plaza was almost wholly surrounded by rooms, and from its position was evidently one of the most popular of all the enclosures of this kind. From the roof of the main building one could probably look over Font's room into this plaza. Although the plaza is a small one, its eastern position would give it considerable ceremonial importance. The accumulated earth was cut down to the original level and removed outside the compound. There does not seem to be sufficient evidence that there was an eastern entrance way to this plaza, although it was looked for when excavations were made.[1]

14. Southwest Plaza

This plaza adjoins the west wall of the compound, extending from the rooms southwest of the main ruin to the first of the cluster of rooms in the southwest angle. Although large quantities of earth were removed from this enclosure, it has not been wholly leveled to the floor, especially on the east side, near a wall which is a continuation of the rooms at the southwest corner of the main ruin. This wall was exposed along its whole length, but showed no rooms on the west side, although probably there are several on the east, or unexcavated, side.[2]

15. South Court

A long court extends across the whole south end of the compound from the southwest cluster of rooms to the east wall. Its form suggests a ball court or course for foot races. In connection with the former suggestion, it is interesting to note that several stone balls, such as were used, according to Pima legends, in a game of kicking ball, were found in this court; this game is still practiced

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[1] The present passageway was cut by the author, and marks the place where the old stage road entered the compound.

[2] A ridge of earth joining this wall with the east wall, upon which the tents of the custodian stand, probably marks the position of a row of one-storied rooms the walls of which have been located on the inner side of the east wall (see plate XXIV).

by the Pimas. Near one end there was excavated a square perforated stone, recalling that through which balls were thrown in the Nahuatl pelota.[1]

RELATION OF EXCAVATED ROOMS TO CASA GRANDE

It is not the purpose of the present article to discuss the architecture of Casa Grande, notwithstanding the fact that the author differs somewhat in his observations and conclusions from those who have preceded him. His interpretations of this subject will be made a prominent feature in the final report, but it may be well in this place to point out the relation of Casa Grande to the new rooms brought to light by the excavations, in order to comprehend the former appearance of the compound.

One of the most important facts to be determined, in order to form in our mind's eye a picture of Compound A in its prime, is the number of stories of the main building. There is a want of uniformity in the statements of the most reliable writers regarding this feature.[2] The majority of the older observers state that there were four stories; the more recent find evidences of only three. Both are correct; but, as has been stated, there is evidence that the lowest or ground story was purposely filled in with solid earth, so that the floor of the lowest room was on a level with the roofs of the buildings around Casa Grande several feet above the base of the foundation wall. In other words, when Casa Grande was constructed the walls of the lowest story were first built to the height of seven feet, and then or later filled solid with "caliche," the top of which is the present floor of the second story. Later the walls were carried up to the desired height. The reasons for this conclusion are: First, digging into the floor of the building, we found no trace of beams such as would appear were the floor a roof of a lower room; second, in the south and west rooms, where the solid earth has been removed

[1] We have good evidence that this game was known and played by the ancient people of the Casas Grandes in Chihuahua, which would indicate that it was not unknown in the Gila region.

[2] The Pimas have a legend that there were formerly more than four stories, and old residents corroborate this, but there is no evidence that Casa Grande was ever more than four stories high. The same Pima legend that speaks of the main building being more than four stories high says that the walls of the Casa were cut down by a great serpent, which a magician of a hostile tribe had created by drawing a human hair through his mouth. This story may refer to the wall surrounding the compound.

from the lowest story, there is no evidence of smooth plastering on the walls; and, third, there are no evidences of doorways or windows in these walls, as would be necessary were there a room in this lower story. There could not have been windows or doorways, because, surrounding Casa Grande on the north, east, and south sides, about eight feet from the base, there was a retaining wall which formerly, it would appear, rose to the height of the floor of the lowest room. Between this wall and the outer surface of the wall of Casa Grande was a space which was probably filled solid with earth in exactly the same fashion as the lowest story of the main building. This construction formed a platform running around the three sides of the building at the same level or elevation as the roofs of the other one-storied rooms of the compound and floors of the lowest chambers of the main building. Unfortunately, when Casa Grande was repaired this surrounding terrace was cut away, but by digging below the surface of the ground the author found evidences of this retaining wall on the east, north, and south sides.

From this terrace the ancients could pass directly, on a level, through the low doorways into the lowest room; here were probably placed the ladders by which they mounted to the doorways of the second story. We can imagine the part this terrace must have played on ceremonial occasions or market days, when the compound was crowded with visitors, or when dances of religious or secular nature were taking place in the plazas. This supposition of a surrounding terrace, which is as yet only an hypothesis, harmonizes the statements of those who speak of Casa Grande as having four stories and of those who record that it had only three. The latter may have referred to tiers of rooms, while the former recorded the total height, including the solid lowest story or that under the lowest rooms.[1]

When Father Kino first saw Casa Grande he undoubtedly had the impression that the lowest story, like those above it, was not solid, but a room. This conclusion was natural, since there were other rooms then visible, and in a good state of preservation, above ground, on that level, all about the base of the building. As he approached from the east, it would have been natural for him to suppose that the middle of Casa Grande had four stories of rooms, one above another.

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[1] On the northwest corner of Casa Grande there is a row of holes in the outer wall on a level with the top of the supposed terrace, in which rafters may have been inserted.

The roofs of the six ceremonial rooms, as well as the roofs of the buildings just east of Casa Grande, united at one end with the basal terrace, from which it was possible to walk to the north surrounding wall on one side and to the passageway west of Font's room on the east. All the rooms were single-storied, having both lateral doorways and roof entrances so placed as to be advantageous for spectators overlooking the plazas.[1]

COMPOUND B

A few observations made at Compound B may enlighten the reader on the structure of the compound already described. Compound B (plate XXXVI) is situated 748 feet northeast of Compound A, and contains the largest cluster of mounds in the northern part of the area covered by the Casa Grande group. Like Compound A, it is surrounded by many low elongated refuse heaps, which are generally parallel to the walls of the compound.

Although the dimensions of the outer wall of Compound B are smaller than those of Compound A, it encloses a pyramidal mound that conceals a building which will probably be found to exceed in size any house yet excavated in Compound A. The exterior walls of Compound B measure approximately 295 feet long by 165 feet wide and are oriented a trifle east of north. The mounds of this compound and the cluster of smaller elevations near it are among those first seen by a visitor approaching Casa Grande from Florence by the old stage road. This road crosses the southeast angle of the compound (plate XXXVI). Two of the mounds in this compound are of large size, the one the main building and one in the southwest corner of the compound. The mound in the southwest corner is shaped like a try-square, and indicates a building whose walls measure 102 by 82 feet. The main mound has a pyramidal form, its outer walls measuring 90 by 70 feet. Its top is flat and about 8 feet above the base, and the edges are somewhat worn by erosion. There are,

[1] "One of the houses," writes Mange, "is a great building, the main room in the middle being four stories high and the adjoining rooms on the four sides of it being three stories." The figures that accompany Mange's description also show four stories in the middle room and three on the sides, two of the latter having lateral entrances in the lowest story. If these figures are accurate, of course the hypothesis that the lowest story was solid is untenable; but they are not accurate, or at least do not agree with one another. Mange's ground plan of Casa Grande is faulty, for it has seven rooms, while the elevation represents a doorway which does not appear on the ground plan.

in addition to these two larger elevations, other small mounds in Compound B, indicating rooms, and also depressions marking the position of plazas, but the limits of these can only be determined by excavations. The altitude of the highest mound is such that we have every reason to suppose, when the accumulated débris is removed from the plazas and buildings, there will be revealed in it high-walled houses in a good state of preservation. The statement, made by others, that the mounds of Compound B were erected on an artificial platform,[1] is not supported by the author's studies. The course of the surrounding wall, especially at its angles, is well marked, and the evidence is good that the floors of the plazas and the foundations of the buildings are several feet below the surface of the supposed terrace and on a level with the bases of the surrounding wall. No excavations of importance have yet been made in Compound B, which is reserved for work in 1907-08.

Compound B was first mentioned by Captain A. R. Johnston, who, after speaking of the well, noticed the "terrace" and pyramidal mound. "About two hundred yards from this building" (Casa Grande), he says, "was a mound in a circle a hundred yards around; the center was a hollow 25 yards in diameter, with two vamps, or slopes, going down to its bottom. It was probably a well, now partly filled up; a similar one was seen near Mount Dallas. A few yards farther in the same direction, northward, was a terrace 100 yards by 70.[2] About five feet high upon this was a pyramid about eight feet high, 25 yards square at top."

It would seem from the large size of the refuse mounds surrounding this compound that it was inhabited for a long time, but the fact that none of the walls are now standing above ground would indicate that it has been deserted many years. The evidence proves pretty conclusively that Compound B is somewhat older than Compound A.[3]

COMPOUND C

Not much remains of the wall or buildings of the third compound (C) but a section of a surrounding wall which has its longest

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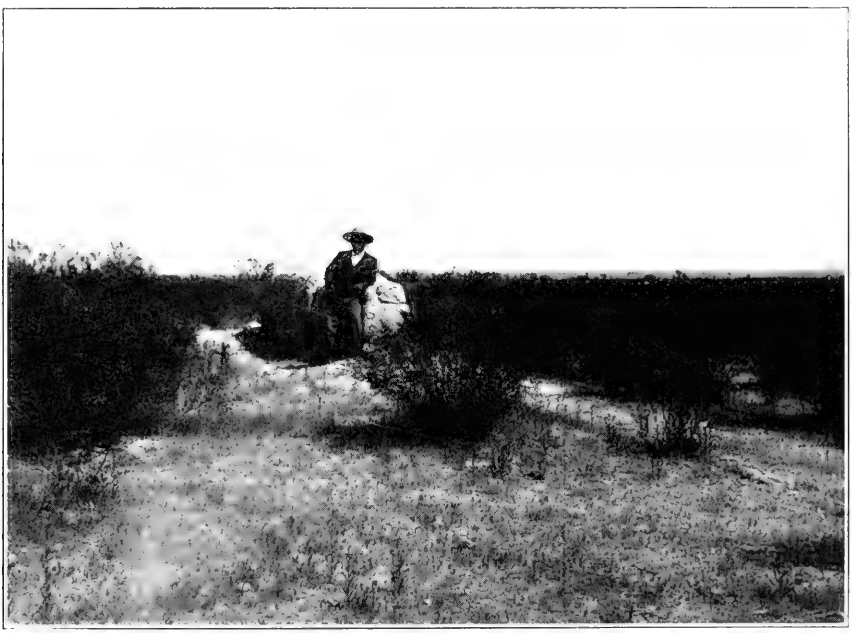
[1] Bandelier (Final Report, pp. 453, 454) gives a ground plan of Compound B, which he calls in his text an "artificial mound resting on an artificial platform."

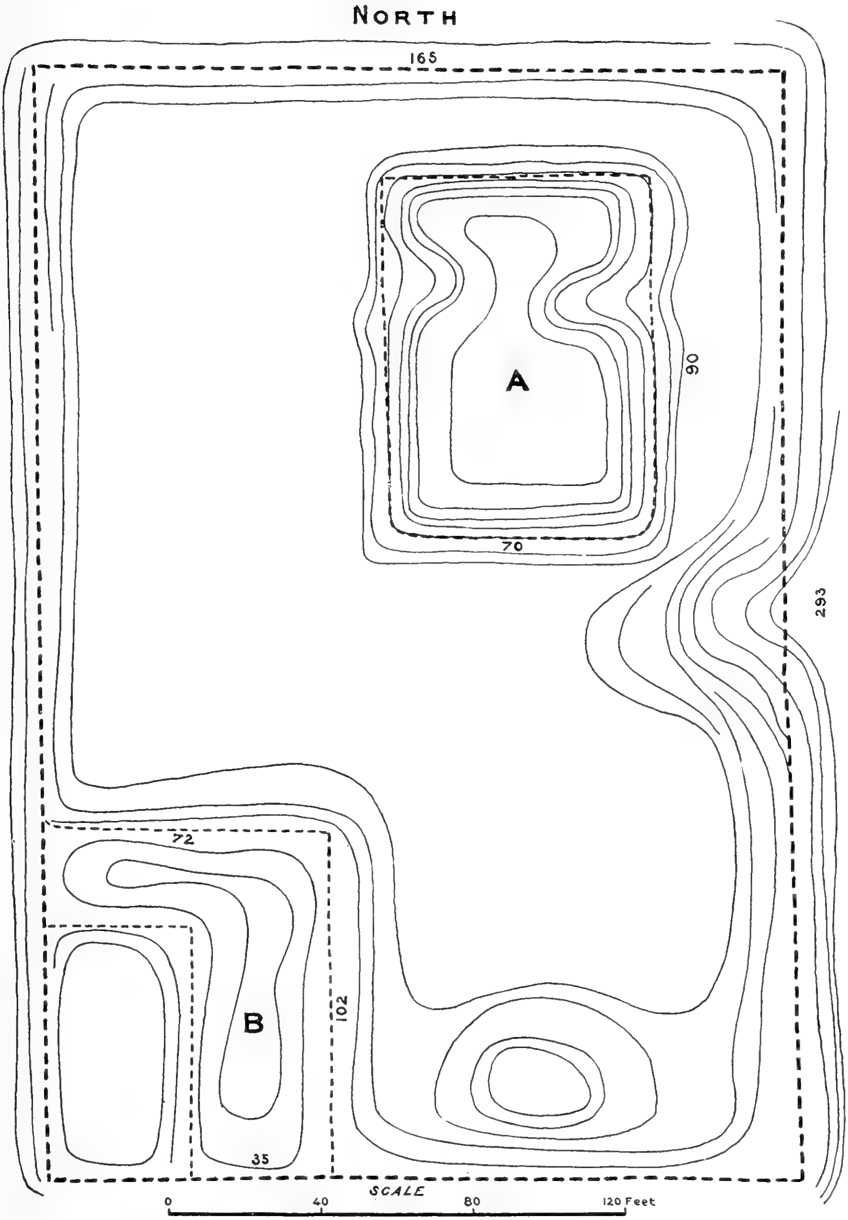
[2] Johnston's measurements of the compound and the enclosed pyramid differ somewhat from those made by the author, especially if the surrounding wall is the same as the margin of the terrace mentioned by the former.

[3] As originally pointed out by Cosmos Mindeleff, 13th Annual Report of the Bureau of Ethnology.

a Compound B from southeast

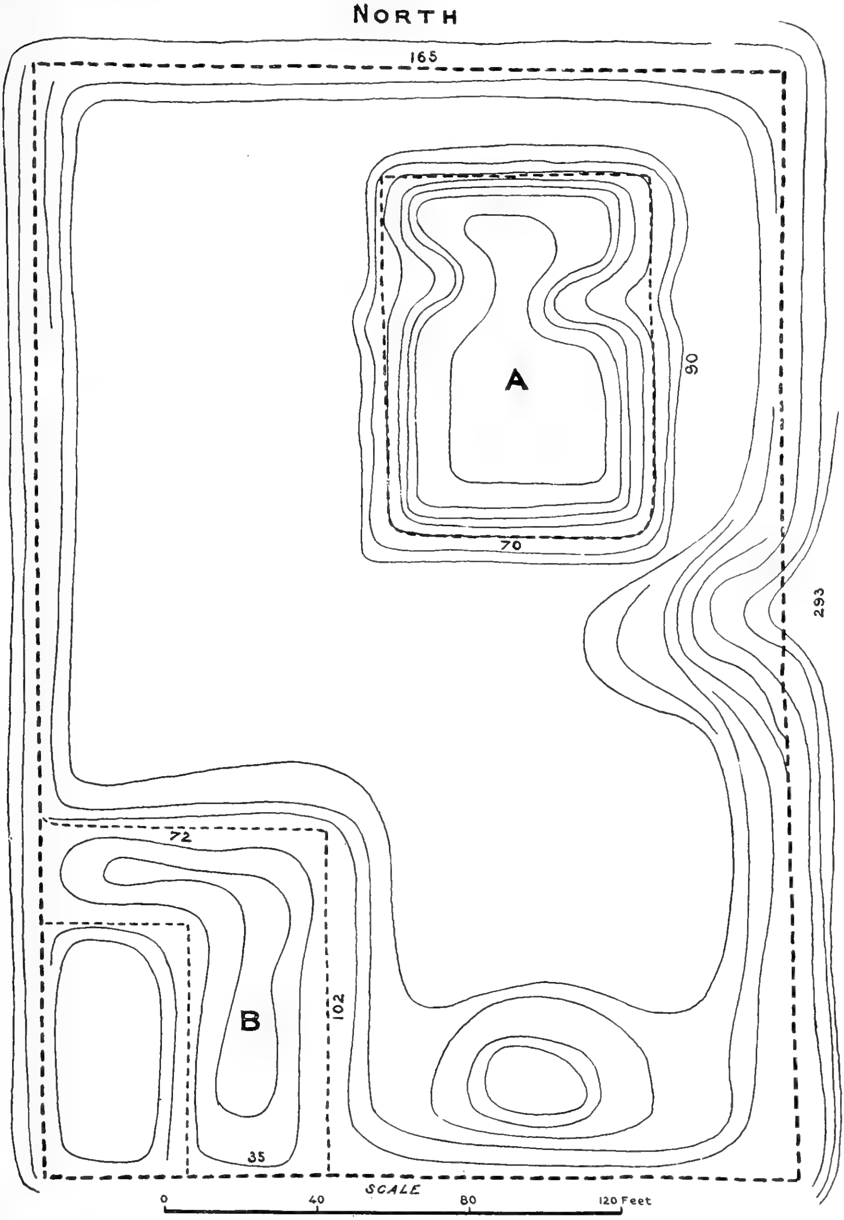


b Section of surrounding wall of compound, five miles east of Casa Grande



A Main building B Building of southwest corner

GROUND PLAN OF COMPOUND B CASA GRANDE (Approximate)



A Main building B Building of southwest corner

GROUND PLAN OF COMPOUND B CASA GRANDE (Approximate)

measurement from north to south. The width from east to west is doubtful. The enclosed buildings of the compound were low, one-storied, and are now quite obscure. This piece of construction, provisionally identified as a compound, is supposed to be older than B, and therefore than A, and would well repay excavation.

OVAL MOUND OR WELL

About 465 feet north of the northeast corner of Compound A is an oval, hollow mound measuring approximately 164 by 95 feet, the longer axis of which runs southeast and northwest. This mound lies almost equidistant from the three compounds A, B, and C and has not been excavated. The various theories of the use of this depression will be considered in the historical part of a final report and need not be dwelt on at this time. Of all suggestions regarding its use, that of a visiting Kwahadt[1] from near Vekol seemed to me the best. This Indian said that in his country there is a similar depression, with steps leading into it, which was once used as a well. Other clusters of mounds in the Gila Valley between Florence and Casa Blanca have similar oval depressions, and the probability is that in all cases they served the same purpose, that of furnishing drinking water to the compounds. Excavations alone, however, will reveal the true purpose of this much debated mound.

CLAN HOUSES

In addition to the great enclosed compounds, there is another class of houses in the Casa Grande group of mounds, Class 2, which are called "Clan Houses." These mounds evidently contain houses generally of the shape of a try-square, but are destitute of a surrounding wall (figure 118). From a distance they closely resemble some of the enclosed mounds of compounds and have the same bare, gray appearance.

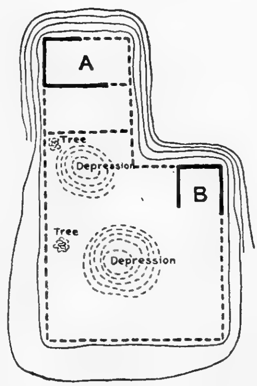


FIG. 118.—Clan house A

The pleasure of excavating one of these clan houses is yet to be experienced, but in repairing the walls of these buildings the author

[1] The Kwahadt are Pimas who live south of the Southern Pacific Railroad, between it and the Mexican boundary. They preserve many ancient Pima customs, and their country is full of shrines and holy places connected with Pima and Papago folk-tales.

was able to observe something of their structure. There are two of these clan houses, A, B, to the east and two, C, D, to the west of Compound A. These differ essentially from the compounds only in that they are small and have no surrounding wall, but as they have no refuse heaps of any size about them, they could not have been long inhabited.[1] Clan houses A and B lie about eight hundred feet east of Compound A.

Although it is very difficult to tell how far to the west the Casa Grande mounds extend, it is believed that clan houses C and D should be included. These two mounds lie to the west of Compound A about six hundred feet and seem to bear the same relation to the compound on this side that clan houses A and B do to the east.[2]

OBJECTS FOUND IN WORK

The collection obtained at Casa Grande numbers not far from 1,000 specimens and contains many objects of interest, adding considerably to the small number from this locality in the National Museum. A detailed account of these specimens is reserved for a final report, but a brief reference to some of the more important may be appropriate at this time. As a general thing, there is a close resemblance in these objects to those used by some of the various tribes of Indians which inhabited the Gila Valley at the advent of the whites. They also show a striking similarity to those found in pueblo ruins in the northern part of Arizona, especially on the Little Colorado. On the whole, the objects found in the rooms are nearer to those of the Little Colorado ruins than to those of the Casas Grandes in Chihuahua or any other Mexican ruin.

The form and texture of the pottery are essentially the same as elsewhere in the Southwest. Bowls, vases, and jars, rough and coiled ware, and smooth painted vessels are common, but no fragment shows a glaze. There is one fragment (plate XXXIX, *a*) with a representation of a bird's head raised on one side that may be classed as an effigy vase. With this exception, there is little likeness in the pottery to that of the Casas Grandes in Chihuahua, although

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[1] Cosmos Mindeleff believed that they were the last buildings inhabited by the Casa Grande people.

[2] The old traditional irrigating ditch of Casa Grande, which lies some distance west of these houses, is said to have its origin from the Gila at the Mexican house on the road to Florence. It is now so filled up that it can hardly be traced.

the architecture and method of construction of buildings in the two ruins are almost identical. A few specimens of small bowls (plate XL, *b*) with three stumpy legs are distinctly Piman, the author not having found this type in his excavations of ruins in northern Arizona, although they are common in Mexico.

The decoration of the pottery is essentially the same as that of ancient pueblo and modern Pima pottery. The figures are generally geometric and rarely have life forms. The broken encircling line, terraced rain-cloud, combined line and hachure (Zuni type), and swastika are some of the common motives. Among the finest specimens are those in white with black decorations—the so-called gray ware. Red pottery with black or brown figures, or with black lines bordered with white make up the bulk of the painted ware. There is one specimen of fine yellow color which cannot be distinguished from the fine Sikyatki pottery.

In one corner of almost every large room stood an earthen water vase of coarse ware, generally red in color and not decorated. Many of these were broken; but one, elsewhere mentioned, was found in the northwest corner of the room adjoining the southwest building. The author discovered a large quantity of pottery and many other objects, among which were basketry and cloth of fine texture, in one of the rooms east of the main building. The depth at which these specimens were found below the surface would indicate that they had been buried a long time and are prehistoric. Their presence in this room, in what was evidently a refuse pile, indicates that the room was not inhabited when these things were thrown there.

One of the rare forms of pottery was a hat-shaped medicine vessel (plate XL, *f*) of undecorated ware, with a flat circular base and flaring rim. Another exceptional specimen was a fragment of a bowl bearing the beak of a bird in relief. A small clay figurine of a quadruped was picked out of the dump of one of the ruins.

The only metallic object found was an unworked fragment of copper. The bells made of this metal that have been picked up on the surface of Casa Grande mounds are in no respect different from similar specimens from ruins in northern Arizona, and may, like them, have been secured by trade from some southern people.

At about four feet below the surface in one of the rooms adjoining the north wall, seven ancient hoes, or planting sticks, were exhumed. These objects (plate XXXIX, *g*) were immediately identified by the Pimas, one of whom had seen similar planting sticks, or hoes, used by the old people of his tribe. Some of the Kwahadts from beyond Vekol said that similar sticks were still in existence in their country, and the author was able to obtain at Casa Blanca two Spanish hoe tips made of iron after the same pattern as the wooden implements here mentioned.

Several wooden paddles (plate XXXIX, *b*) used in the manufacture of pottery were found with the hoes, or planting sticks, and one or two were dug up elsewhere. These implements are identical in form and size with the pottery paddles still used by Pima potters.

The stone objects and implements found at Casa Grande are axes (plate XXXIX, *c*), metates, grinding-stones (plate XXXIX, *f*), stone hoes or spades (plate XXXIX, *d*), arrow heads, paint-grinders (plate XXXIX, *f*), and various other specimens. Paint of various colors, beads made of turquoise, and flat slabs of stone for pigment grinding are numerous. Stone balls (plate XXXIX, *e*) like those used in modern Pima games, and round or oval stones upon which the ancients fashioned pottery are represented in duplicate. Of ceremonial stones there are not a few—quartz crystals, botryoidal stones, concretions, and other forms.

An exceptional stone object (plate XL, *c*) from near Casa Grande was purchased by the author. This specimen has a conical shape formed by two serpents sculptured as coiled together, their heads being at the apex of the object. It was probably a pigment-grinder, but reminds one of the coiled stone cast of the interior of a fossil shell, in the shrine at Walla, which is situated half way up the East Mesa Hopi trail from the plain to Hano. It is also similar to the "Heart Twister," or coiled stone fetish of the Awatobi Mazrau Society, now in the Berlin Museum.

The object shown in plate XL, *d* is a paint slab surrounded by a margin in which are parallel grooves, as in the ceremonial stone slabs from Pueblo Viejo, which the author has elsewhere[1] described.

Plate XL, *e* represents a figure of stone, similar to several other in the collection, made of lava rock with a depression on each side, but of unknown use.

Numerous marine shells and specimens made from the same material occur in the collection. Among these are tinklers manufactured from the spires of conus and rings and bracelets of pectunculus, abalone, and turritella shells. One of the best finger-rings is nicely etched on the outer surface. A shell carved in the shape of a frog

[1] 22d Annual Report of the Bureau of American Ethnology, p. 185.

(plate XL, *a*) and another representing a bird indicate that the artists of Casa Grande were not inferior to those of the old pueblos of the Little Colorado in this kind of work. None of the shell objects differ greatly from those found in the ruins of northern Arizona. In one burial there was a bowl full of marine shells. A perforated pectunculus (plate XL, *g*) from another interment is identical with many specimens from Homolobi, Chevlon, and other ruins of the Little Colorado drainage. Several specimens of bone were taken from the rooms, but not as abundantly as in some other ruins the author has excavated. A fine dirk, apparently made from a deer bone, was taken from the collar-bone of a skeleton of a man; it was so placed that the point rested over the heart.

There formerly grew along the banks of the Gila a reed which was used by the people of Casa Grande for arrows and coverings for the beams of their floors and roofs. In the third from the main ruin of the six ceremonial rooms, a great many reed cigarettes were found. Each of these was about an inch and a half long, wrapped with a woven band by which it was held when hot. The reed was filled with tobacco and was smoked ceremonially, the priest sending forth smoke to the cardinal points. All the reed cigarettes which were found were burned or charred, and lay in one corner of the room.[1]

SKELETONS

Human skeletons were found buried a few feet deep in mounds outside the compounds and under the floors of houses. No evidence of cremation was observed, but of such bodies as were found some lay extended at full length, others with leg bones drawn up to the breast. The remains were usually accompanied by a few mortuary objects.

OTHER RUINS NEAR THE CASA GRANDE GROUP

The Casa Grande group of mounds is not the only one of its kind in the Gila valley. The traveler on the road west from Florence will frequently have his attention drawn to similar mounds which loom above the mesquite and sage bushes as gray elevations bare of

[1] In the memory of several of the old Pimas, similar reed cigarettes were smoked when they went to war. The same kind of cigarettes is still employed by the Hopi in some of their ceremonies, and are deposited at cave shrines in the Superstition Mountains, north of Casa Grande, showing that they were sometimes offered to the gods after use.

vegetation and easily distinguished from natural hills by the fragments of pottery or worked stone upon their surfaces. The artificial character of these mounds, suggested by their form and superficial appearance is proved by the walls which sometimes project from them above the surface of the ground. Even when these walls are worn down to a level with the earth so that they appear to be absent and are difficult to discover, it is possible to follow them because of their hardness, compared to the surrounding earth. In the springtime the tops of these walls can be traced with ease by the distribution of small annual plants in their vicinity. After the early spring rains these plants sprout almost spontaneously out of the soil, growing luxuriantly to the very edges of the walls, where they cease, not being able to send their tender rootlets into the hard, moistureless grout of the wall. Although the spade may uncover buried walls in many instances, the majority of these mounds are found to be made up of earth or débris containing many broken fragments of pottery, battered or polished stones, and other artificial objects. Now and then one encounters a mound much larger than the others, surrounded by a low ridge of earth slightly elevated above the surface. At first sight, some of the larger mounds appear to rest on artificial platforms, which is due to the fact that one side of the enclosed building is partly formed by the surrounding wall, but none of the Gila ruins examined by the author show conclusive evidence that buildings were erected on such platforms, as has been sometimes surmised.

Let us first consider a few of the mounds resembling Casa Grande, in its immediate neighborhood, beginning with that near Florence.

To the left of the road west from that town there is a small cluster of Papago huts,[1] near an ancient mound of considerable size. Although a few unmethodical excavations have been made in this mound, they have revealed nothing of archeological value, and have somewhat injured the walls. The Florence mound is still in a fair state of preservation, and would well repay systematic excavation.

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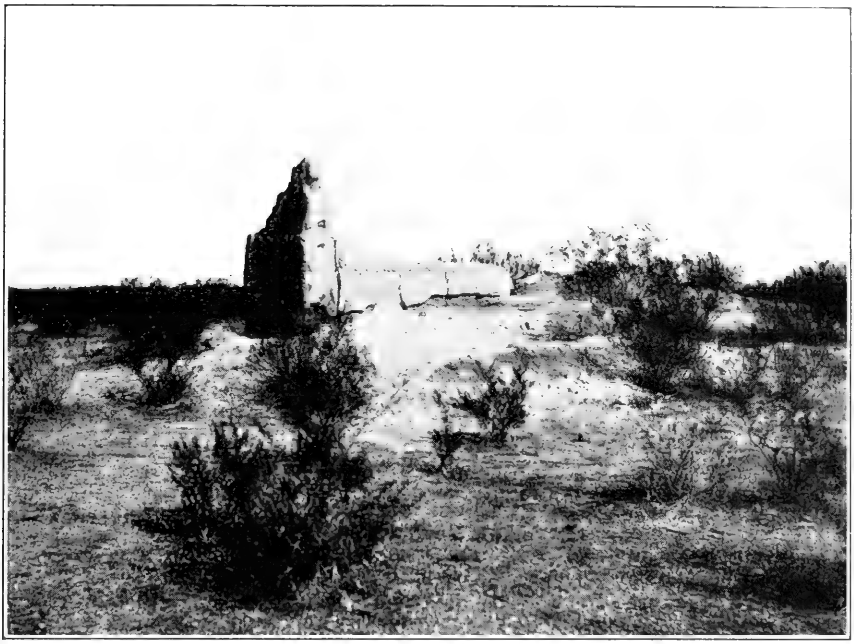
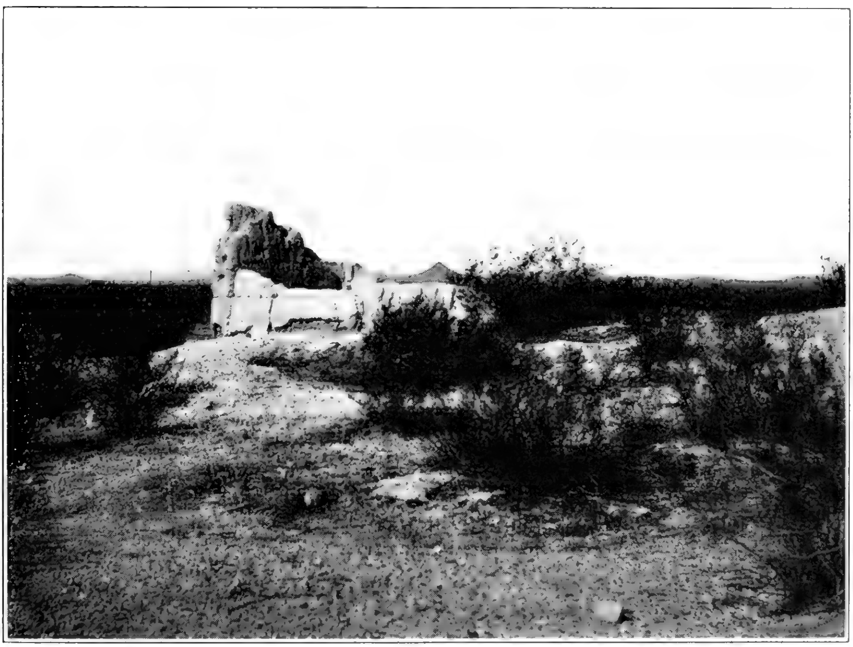
[1] The Pimas of the settlement, Blackwater, near Casa Grande, claim that this Papago settlement is not very old and deny that its inhabitants are direct descendants of those who built the walls of the neighboring ruin. Blackwater is, however, not an old settlement, but is near that mentioned as follows, by Mange: "On the bank of the river Gila at a distance of one league from the Casas Grandes we found a rancheria in which we counted 130 souls, and preaching to them on their eternal salvation the father baptized nine of their little ones, although at first they were frightened at the horses and soldiers, not having seen any till then."



a View of standing walls



b View of same from southeast

CLAN HOUSE A OF ADAMSVILLE GROUP

Situated on the mesa, about a mile south of Adamsville and five miles from Florence, there is another cluster of mounds (figure 119), one of which may be called a compound, since it is surrounded by a wall 271 by 173 feet. The three sides of a clan house ruin rise on another of these mounds (plate XXXVII, *a, b*). Its walls, which measure 25 feet long by 13 feet wide, above ground, are now badly

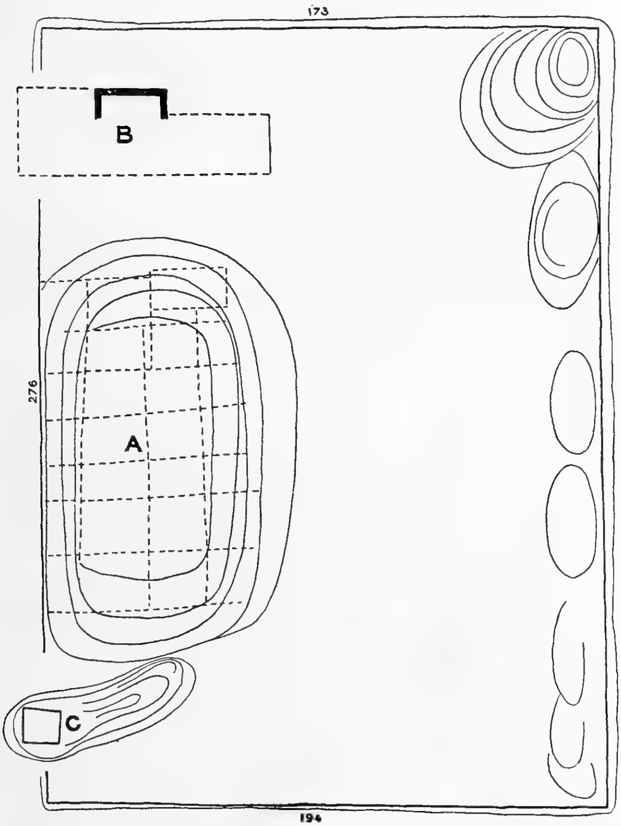


FIG. 119.—Adamsville Compound; A, mound, B, C, clan houses

eroded at their base. Another of these mounds, oval in form, may have served as a well, for it has a central depression and sloping sides at each end of the longer axis.

The mound near Sweetwater (figure 120), about five miles west of Sacaton, is small and low, rising but slightly above the surrounding plain. It shows no remnant of its walls above ground, but, so far as they can be traced on the surface, they measure 232 by 173 feet.

On the road from Casa Blanca to Sacaton the author's attention was drawn to the grave of an old Pima medicine man near an ancient cemetery, which may throw light on the meaning of certain rectangular figures made of small stones found elsewhere in the desert. The grave was a rectangular enclosure oriented to the

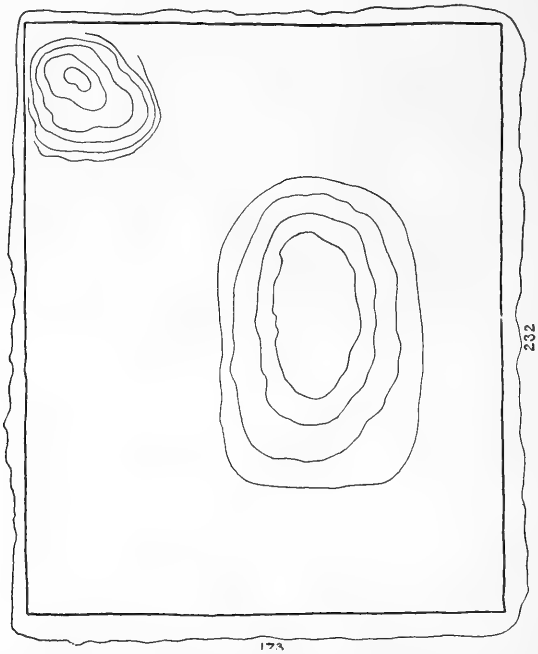
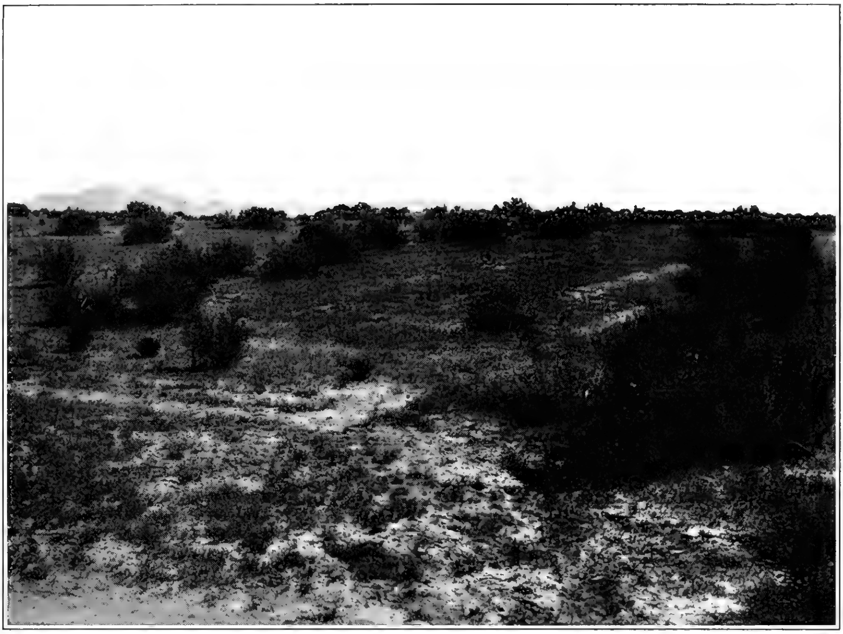
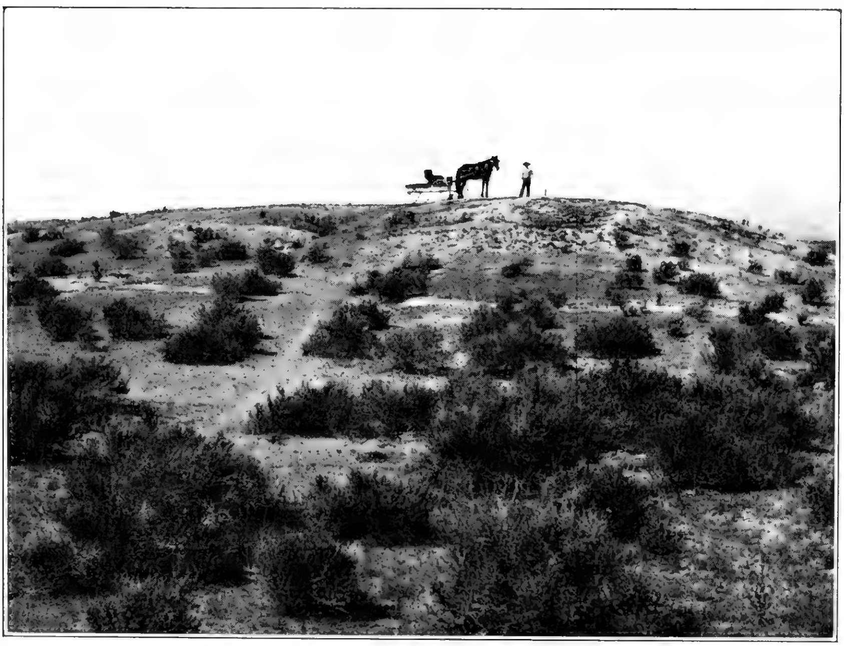


FIG. 120.—Ground plan of Sweetwater Compound

cardinal points, made of small stones, each side being about 20 feet long, with an opening in the center of each side, where there were formerly sticks stuck into the ground. The dead man was buried in a sitting posture within the enclosure, not far from the middle. His face was blackened, and he is said to have been decorated with a head-dress of feathers. Digging a foot below the surface, many beads (former offerings) were found by the author. The guide said that his father used to make offerings at this place, and that *he* believed the magic power of the medicine man could control the sun.



a Angle of surrounding wall, as indicated by failure of vegetation



b Main mound, showing walls not excavated

CASA BLANCA COMPOUND

In sight of the Adamsville cluster, a mile to the west, rises a large mound of the same general character as a compound, which is especially instructive because of the remains of sections of the original surrounding wall[1] which are still standing (figure 121). This wall (plate XXXV, *b*) is five feet high and is identical in kind of material and mode of construction with the surrounding wall of Compound A of the Casa Grande group. It consists of two sections, both on the east side and about forty feet apart, the larger, situated twenty-five feet from the southeast corner, being seventeen feet long. The length of the east wall is one hundred and seventy-four feet, that of the

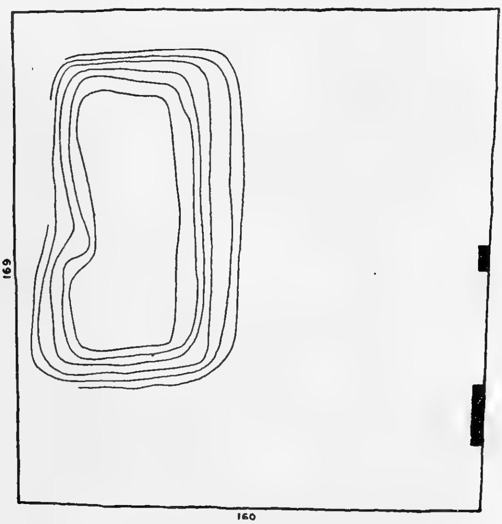


Fig. 121.—Ground plan of Compound between Adamsville and Casa Grande

west one hundred and sixty-nine feet. The south wall of the enclosed building is about fifty feet from the south wall of the compound.

The famous Casa Blanca, or White House,[2] situated about twenty-five miles west of Casa Grande, is one of the most extensive ruins in this part of the Gila valley. The largest mound of this cluster was formerly surrounded by a wall within which were two or three

[1] If the fragments of standing wall in this ruin are not soon protected they will fall to the ground.

[2] Casa Blanca is called by the Pimas Tcoktatai civanaᵃvaki (The House of Chief Black Sinew). The adjacent settlement may be the "Sutaquison" of early Spanish authors.

other artificial elevations. Casa Blanca, like Casa Grande, had its oval mound with well-like interior,[1] besides several other elevations of earth débris. The accompanying plate (XXXVIII, *a, b*) represents Casa Blanca from the east, showing, *a*, one angle of the unexcavated surrounding wall as it appeared to the author in March, 1907. No walls now stand above ground, although it is said that

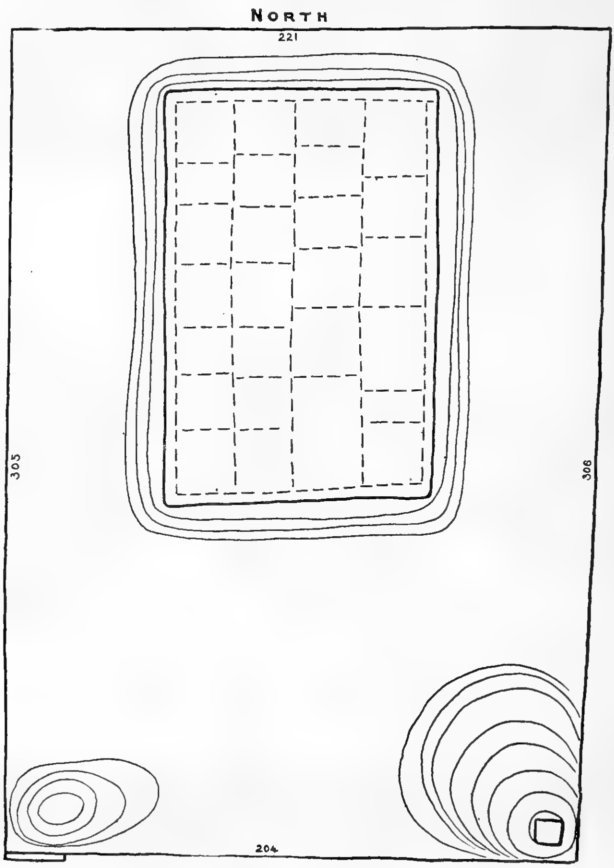


FIG. 122.—Ground plan of Casa Blanca Compound

portions of buildings were visible as late as the middle of the eighteenth century, and perhaps later.

The surrounding wall (figure 122) measures 305 feet on the long

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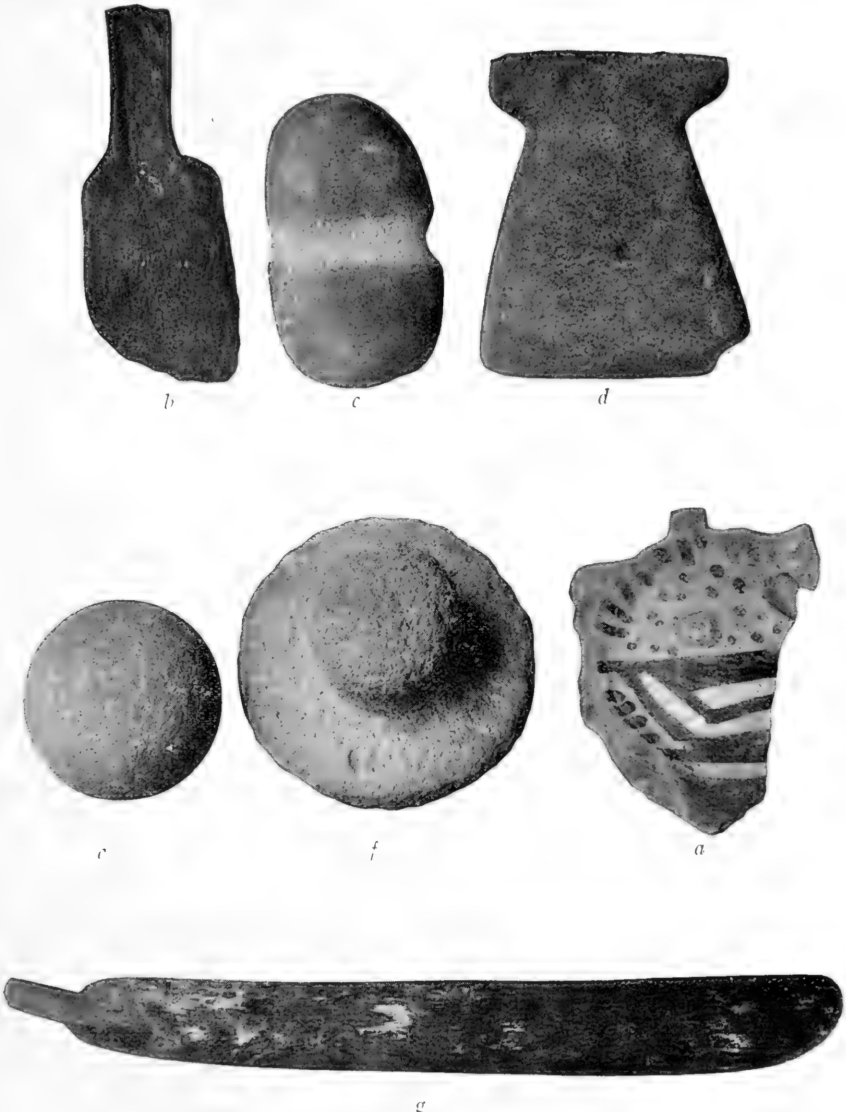
[1]According to Hinton, Handbook to Arizona, p. 413, "There is one large circular enclosure still to be seen near the stage road and within gunshot of the Casa Blanca trading post."



a Fragment of vessel with painted bird's head (clay; length, 4¼ inches)
b Wooden pottery paddle (6¼ inches x 2½ inches)
c Double edged stone axe (length, 4¼ inches; width, 2¾ inches)
d Stone shovel (length, 5¼ inches; width, 4¼ inches)
e Stone ball used in game (diameter, 2½ inches)
f Stone paint grinder (height, 2½ inches; diameter, 4 inches)
g Wooden hoe (3 feet 2½ inches - 4⅜ inches)

OBJECTS FROM CASA GRANDE MOUNDS

a Pectunculus shell, carved to represent a frog (surface); (length, 2 inches)
b Clay saucer with three legs (height, 2½ inches; diameter, 5¼ inches)
c Carved stone serpents (surface); (length, 2⅛ inches; diameter, 1½ inches)
d Stone slab for paint grinding (length, 3 inches; width, 1¾ inches)
e Problematical stone (surface); length, 3½ inches)
f Clay bowl (height, 3 inches; diameter, 6⅛ inches)
g Perforated pectunculus shell (diameter, 2 inches)

OBJECTS FROM CASA GRANDE AND NEIGHBORING MOUNDS

side and 306 feet on the opposite side.[1] It is 221 feet on the north side; 204 feet on the south. The large enclosed building is composed of many rooms, approximately 140 feet on the east by 147 on the west sides; 69 feet on the north, and 87 feet on the south. Its northeast angle is about 37 feet from the east wall, and its southeast corner not far from 49 feet from the same side. The main mound has many rooms, is about 20 feet high, flat on top, and visible from a considerable distance. The north wall of the main building is about 18 feet from the north wall of the compound. The Casa Blanca mound is the largest within 30 miles of Casa Grande.

On or near the right bank of the Gila there are likewise several artificial mounds between the limits above mentioned. This series, beginning near the Santa Fé Railroad station, is represented by certain mounds near Blackwater and at Santa Anna, opposite Sacaton and beyond. The ruins near the Santa Fé station were probably known as far back as Kino's time, being those mentioned in the following quotation from Mange's diary.[2]

"On the 18th we continued," writes this author, "westward across an extensive plain, barren and without pasture, and at a distance of five leagues we discovered, on the other side of the river, other houses and buildings. Sergeant Juan Escalante and two companions swam across to reconnoitre, and reported that the walls were two yards thick, but all of ancient workmanship. We continued westward, and after making four more leagues we arrived at noon at the Casas Grandes, in which Father Font said mass, having till then kept his fast."

The narrative that follows the above quotation contains a good description, with measurements, of the main building, showing that Casa Grande was four leagues west of the position of the command when Escalante left it.[3] Counting four leagues east from Casa

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[1] Some of the walls project a little above the ground on top of the mound, and the same is true of the southern wall of the compound.

[2] Documentos para Historia de Mexico, Cuarta Serie I, 250, Mexico, 1856. Ortega. Apostolicos afanes de la Compania Jesus escrito por un Padre de la misma sagrada religion de su provincia de Mexico, Barcelona, 1754, p. 253.

[3] Apparently Font followed the Santa Cruz River down to Uturituc (Tutiritucar), near Blackwater, leaving Casa Grande to the right. From Uturituc he visited the old ruin, Casa Grande. His party had apparently crossed the mountains near Picacho Peak by the pass through which now runs the Southern Pacific Railroad, stopping at "Aquituno" or Akutcin, a Pima settlement inhabited up to within a few years. Picacho is called by the Pimas Takom, which appears in some of the older narratives as Quitcak, Ttacca, or Mt. Taceo. About it are several ruins, one of which is supposed to be Aquituno.

Grande, or in the direction Kino approached it, would bring one to the neighborhood of Florence, or about opposite the mounds near the railroad station. Evidently this was the place where Escalante and his two companions left the main force and swam the river to examine ruins on the opposite side.

The Pima Indians call these ruins *Vaᵃki*,[1] but also sometimes designate them *Civanᵃvaᵃki*, to which is prefixed the name of some chief or other great man. Thus Casa Grande is called Sial'tcutuk civanᵃvaᵃki, the ancient (?) house of chief (?) Morning Green (Blue). The meaning of the word *Civanᵃ* is unknown. The older Pimas gave this name or some modification of it to Kino and Font, the latter of whom translated it "Hombre Amargo," Bitter Man, *civ* in Pima meaning bitter. It has been customary to consider *Civanᵃ* as the proper name of a chief, but this is not wholly warranted, especially as the word prefixed to *vaᵃki* is employed to designate several other ruins besides Casa Grande, where it is also used with a special name of a chief, as Black Sinew, String, and White Feather. The author supposes that *Civanᵃ* is an old, perhaps archaic, word for chief or ruler.

Conclusions

The scientific results of the work at Casa Grande in the winter of 1906-07 cannot be sufficiently elaborated in a short preliminary article, but they may be in part briefly stated as follows:

Many rooms have been discovered in the surrounding mounds on a level below that of the lowest floor of the main building. These rooms, like Casa Grande, are enclosed by a common wall, the rectangular enclosed area being called a compound. Some of these newly discovered hòuses are larger than Casa Grande itself, but not one of them has the same number or distribution of rooms. The houses are so constructed that their roofs were on a

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[1] The significance of the word vaᵃki is also obscure. *ki* in Pima and Hopi means house; *vaᵃki* recalls the Hopi *patki*, a name applied to those Hopi clans which are said to have come to Walpi from Palatkwabi, or the Giant Cactus country, supposed to border the Gila and Salt rivers. The Hopi claim that some of the Patki clans built the Great Houses of the Gila, Verde, and Tonto valleys is trustworthy and can be verified by archeology. As the Pimas hold that the former inhabitants of the Tonto Basin spoke their language, it is logical to conclude that the ancestors of some of the now composite Hopis were practically in the same culture as the ancestors of some of the Pima clans, and that they were the Ootam or builders of the Great Houses of the Gila and Salado valleys.

level with the lowest floor of the old ruin. The basal story of Casa Grande was made solid by filling in earth between the foundation walls already constructed. Two buildings, Font's room and the cluster in the southwest angle of the compound, were two stories high, but all others, except of course the "Great Casa," were single-storied. The size, structure, and contents of the new rooms indicate that they were erected for public gatherings, and that domiciliary use was subordinate to public use.

The excavations contribute little to our knowledge of the age of Casa Grande. No object of European manufacture was found in the excavations, and the specimens obtained add nothing which would be of aid in determining either the time Casa Grande was built or when it was deserted. The specimens do not indicate Aztec culture or that of any other Mexican race, and suggest no culture higher than modern Hopi or old Pima. While the question as to who built Casa Grande remains as difficult to answer as ever, archeology supports Pima traditions in affirming that the builders of Casa Grande were the ancestors of the Hopis, Pimas, or some closely allied stock.

Some of the rooms of the compound were constructed on the same plan as old Pima houses. They had in the floor two upright logs set at equal distances from the walls to support the roof. Upon these upright logs was placed a median horizontal ridge pole, bearing rafters arranged side by side, the whole being covered with reeds upon which was a thick layer of beaten clay.

Almost every specimen found in the diggings was immediately identified by the Pima laborers, so close was its resemblance to objects used by the old people of their tribe. Thus, the stone balls frequently found are identical with those still used in a kicking game.[1] The wooden hoes and paddles are identical with similar utensils of the Pimas used within the memory of the old people. The reed cigarettes are the same kind as those made by Pimas

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[1] The old Pima Indian, "Thin Leather," declared that a favorite game of the Casa Grande girls was called *toka,* and that the cane game *kiuskwut* was also known to the inhabitants of Casa Grande.

In the game *toka* a rawhide rope, knotted at each end, was thrown with sharpened sticks, the contestants being divided into two parties facing each other, a hundred feet apart. It was while the girls of Casa Grande were playing this game that the daughter of Morning Green was abducted by a chief from Gila Crossing.

when they went to war with the Apaches, even after the coming of the whites.[1]

The relation of the builders of the rooms, revealed by the excavations, to modern pueblos is shown in the designs and general character of the pottery, stone implements, shell ornaments, and ceremonial objects. Although the materials used in construction of the walls are identical with those adopted by the builders of the Great Houses of Chihuahua, the pottery, with the exception of the bird-faced vase, of the two localities is quite different. In the Chihuahua Casas Grandes the grouping of the buildings into compounds is not evident; house burials are common to both localities.[2]

There is no foundation for an almost universally accepted statement[3] that a people of superior culture inhabited the Gila Valley, or that Casa Grande was built in very ancient times. The people of the Casas Grandes were not very distant relations of the Aztecs and their kindred, but there is no evidence that Casa Grande was one of the "stations" of the early migration of this people.

From the advent of Europeans, at the close of the 17th century, to the present time, Pimas residing in the neighborhood of Casa Grande have told their legends of it to visitors. Naturally many of the present generation of Indians have declared their ignorance of the makers of the Great House, for only a few, rapidly diminishing in numbers, know the old legends. One or two of the oldest men and women relate stories of the inhabitants of Casa Grande, its chief, and his daughters. The author has collected several of the more important of these legends from an old Pima named "Thin

[1] Similar reed cigarettes are employed by the Hopis in their ceremonies. Thin Leather claimed that he had in his youth smoked similar reed cigarettes when he went on a war party; that they were kept in a bag and were not used in rain ceremonies. Sala, the best Pima potter, who spent some time at Casa Grande during the author's work there, in order to get new inspiration in her art, said she had seen hoes or planting sticks similar to those found in the ruin, used by the Kwahadt.

[2] It is stated that the River people (Pimas), Desert people (Papagos), Kwahadt, and Rabbit Eaters are all the same stock, called Ootam (people), the ancients who built the Great Houses. Pima legends tell of the southern migration of the so-called Rabbit Eaters, an offspring of the Pimas, into Mexico in early times. The southern migration of the Rabbit Eaters may have given rise to the story of the relation of the inhabitants of the Gila to the ancient Aztecs.

[3] This theory occurs in many writings of the 16th and 17th centuries, from the time of Ortega, Kino's biographer, or earlier, and undoubtedly accounts for the name, Casa de Moctezuma, applied to Casa Grande.

Leather" and from others, who affirm that the builders of Casa Grande were of Pima blood and spoke the Pima language.

The burden of Pima legends of Casa Grande is that the chief, Morning Green, was a powerful medicine man who controlled the wind and rain gods and accomplished many marvelous deeds by his magic. He was supposed to have been a son of Tcuhu, a cultus hero, sometimes called Moctezuma, and to have had a parthenogetic birth. His two daughters, Van and Natci, were married to neighboring chiefs, the former having been abducted by the ruler of the Great House near Tempe or Mesa during a sacred dance.

The art of irrigation was taught to the Casa Grande people, so the story goes, by the people of the Great Houses on the Salt River, whose irrigating ditch near Mesa was made with the supernatural aid of the woman who controlled hard materials,[1] as stone, shell, turquoise, and other like substances. Her home is reputed to have been among the Maricopas, which is another way of declaring that she came from a tribe living farther down the river.[2]

None of the Pimas whom the author interrogated ascribe the building of Casa Grande solely to the Hopis, for they know very little about the "Moquinos" or Hopis, although they have stories of relatives in the north. One of the most intelligent among them informed the author that his father told him there were formerly people in the northern part of Arizona who spoke the same language as himself, and that the ancients who lived in Tonto Basin were relatives of the Pimas.[3] He likewise said that the word *moki* is good Pima and derived from *mo,* dead, and *ki,* home. It occurs to the author that the ancient Pimas answered the Spanish question regarding the people of the north with the word *moki,* meaning to say that the people who lived in the north had perished.

It is instructive in this connection to note that the Pimas have a legend which recalls a story repeated among the members of the *patki* clans of the Hopis. According to this legend, water at one time mirac-

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[1] This woman, Towa kwaotom ochse, is practically the same as the goddess Huzriwuqti of the Hopis.

[2] The story of how the rain and wind gods were expelled from Casa Grande and how Morning Green brought them back is one of the most ancient Casa Grande legends. Practically the same story told to Font in 1775 was repeated to the author, a highly suggestive illustration of the persistence of folk-tales.

[3] The author believes that the word Totonteac is a Pima word from *tonto,* crazy, *toac,* locative, and that this province was not the modern Hopi country, but Tonto Basin. The root of the word *pima* is probably the same as that of the Hopi word *pii,* I do not know.

ulously spouted out of a hole in the ground, and a sacrifice of children was made to stop the flow. The place where this occurred is still pointed out and is called "Where the women cry" (for their children). It is situated far south of Casa Grandes, among the Kwahadts.[1] Evidences from both archæology and migration legends are corroborative, and point to ancestors of both Hopis and Pimas as original inhabitants of Casa Grande and other *vaaki* of the Gila Valley between Florence and Casa Blanca.

But if that is true, why, it may be asked, have the Pimas lost the custom of building great houses, and why did they inhabit such small huts when the Spanish explorers came? In reply, it may be said that they were forced to abandon their great houses, being unable to defend them on account of their unwieldy size. Hostile invaders found these conspicuous structures easy prey and broke up this phase of Pima culture, scattering the chiefs and defenders of the compounds.[2] But, although scattered, they still held to the inconspicuous huts in which the common people had always lived. They abandoned their great houses, or temples, storehouses, and citadels, but still lived in the same kind of houses as before. This apparent change of culture is paralleled among other sedentary tribes of the United States and Mexico. Forced to desert their temples and great houses, the people still clung to the only houses they ever had—the inconspicuous huts, in which nothing remained to tempt the cupidity of their enemies.

The preceding conclusions may be summarized as follows: In ancient times the valleys of the Gila and its tributaries as far down river as Gila Bend were inhabited by an agricultural people in a homogeneous stage of culture. There existed minor divisions of this stock, as Sobaipuri, Pima, Opa (Cocomaricopa), and Patki. The Pima name Ootam may be adopted to designate this ancestral stock, to which may be ascribed the erection of the Casas Grandes of the Gila.

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[1] Many of the legends are connected with locality in the country of the Kwahadt, a group of Indians who speak the Pima tongue, living far south of the Southern Pacific Railroad, on the borders of Mexico. The "Kwahaties" are clever potters and basekt-makers and form the most primitive of all the Pima communities.

[2] The ancestors of the Patki clans of the Hopis were closely allied to, if not identical with, the ancient Pimas. We may regard the "Ootam," or builders of Casa Grande, as ancestors of both Pimas and Patkis. Some of these ancestral clans may have gone to Zuni, which explains the claim, if any there be, of the people of this pueblo that their ancestors built the Great Houses of the Gila.

These great houses were places for refuge, ceremony and trade. They were inhabited and ruled by the chiefs whose names they bear. The people dwelt in small huts of perishable character, not unlike the old Pima round houses, a few of which still survive.

In the course of time hostiles bent on pillage swarmed into this region from east and west and drove the agriculturalists out of their Casas Grandes. But, although dispersed, they were not exterminated; some of the refugees migrated south into Mexico, others followed the Verde and Tonto into the northern mountains, others still remained in the Gila Valley and were the ancestors of the present Pimas, Papagos, and Kwahadts; those who went north, later peopled the now ruined houses in the Little Colorado Valley and ultimately joined the Hopis, with whom their descendants still live.

NOPALEA GUATEMALENSIS, A NEW CACTUS FROM GUATEMALA

By J. N. ROSE

Among the interesting cacti which have been sent from Guatemala in recent years is *Nopalca guatemalensis,* of which good herbarium specimens, living plants, and photographs were obtained by Mr. Wm. R. Maxon. Photographs were also sent by Prof. W. A. Kellerman and Prof. H. Pittier.

The two habit photographs taken by Mr. Maxon here reproduced represent a young and an old plant, while the other, taken by Professor Pittier, shows flowers and fruit. (Plates XLI, XLII.)

The genus *Nopalea,* although closely resembling Opuntia in habit, has very different flowers and seems to be distinct. Five species are generally recognized, all of which are quite different from the following:

NOPALEA GUATEMALENSIS Rose, sp. nov.

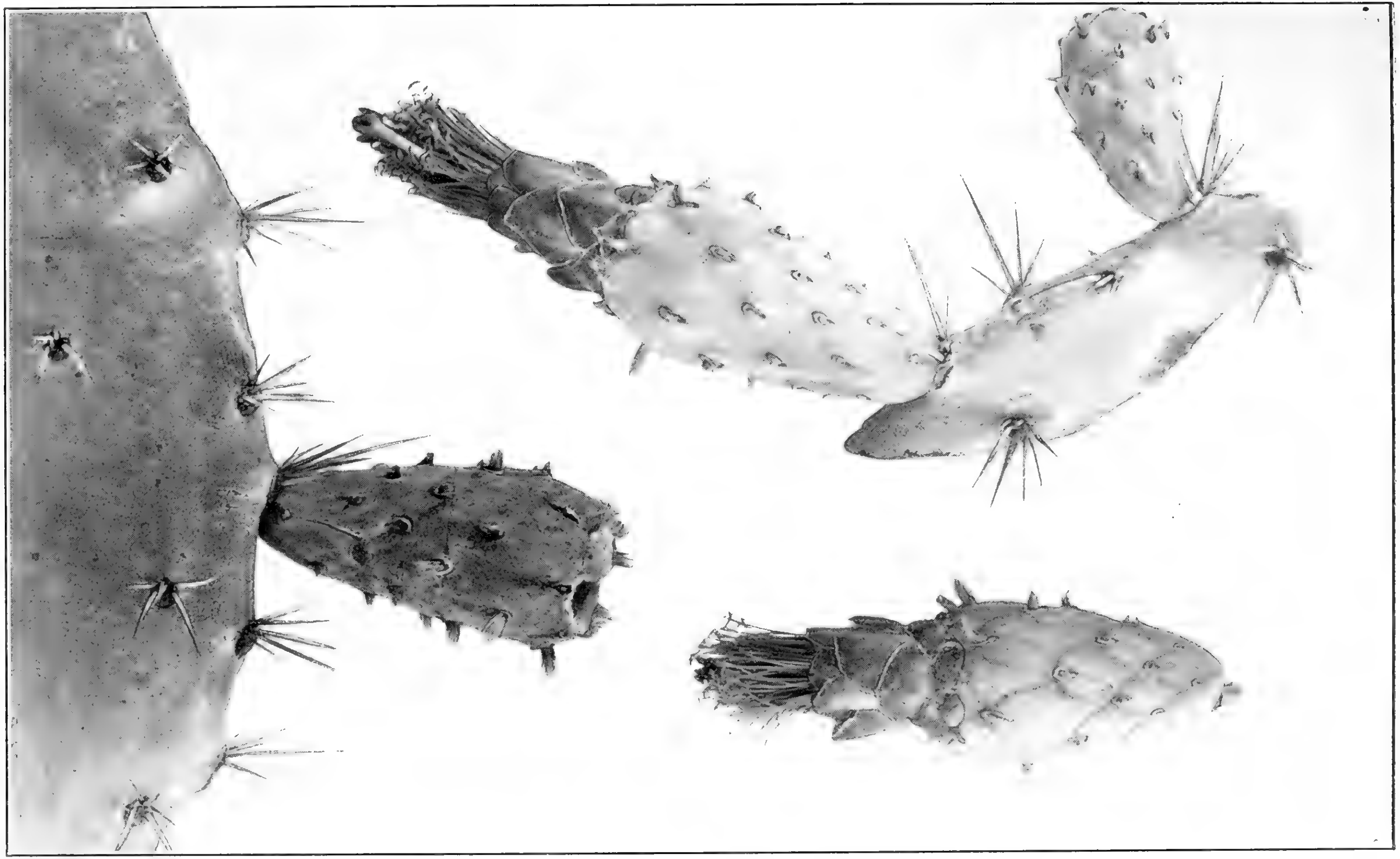
Arborescent, 5 to 7 meters high, much branched; joints ovate to oblong, the lower ones much thickened, the upper and younger ones thinner, 15 to 20 cm. long, blue green in color; areolæ numerous, very spiny; spines 5 to 8, very unequal, the longest ones 3 cm. long, all standing out from the joints, white, the tips darker; leaves linear, reflexed, acute; sepals broadly ovate, thickened; petals reddish (?), about 1 cm. long, erect; stamens exserted; style much exserted; fruit clavate, the surface more or less tuberculate, red or "wine-colored," 4 to 5 cm. long, with a deep umbilicus.

Collected by Wm. R. Maxon near El Rancho, Guatemala, altitude 270 meters, April 5, 1905 (no. 3774, type).

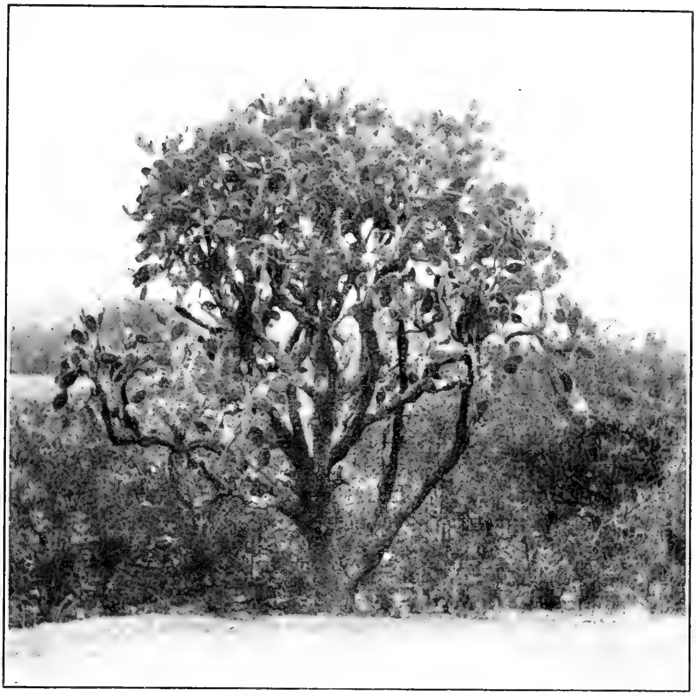
In addition to the herbarium material, Mr. Maxon obtained living plants and fruit and flowers brought in formalin, while Prof. H. Pittier collected flowers and spines and preserved them in alcohol.

Type in U. S. National Museum, no. 473,713.

The spines described are from flowering joints. As the joint grows older, the number of spines increases until 25 or more are produced from a single areole. This is not an uncommon occurrence with certain arborescent species of *Opuntia* and *Cereus.*



NOPALEA GUATEMALENSIS Rosé



NOPALEA GUATEMALENSIS Rose

PERESKIOPSIS, A NEW GENUS OF CACTACEÆ

By N. L. BRITTON and J. N. ROSE

After a number of years observation in the conservatory and field, we are convinced that the subgenus Pereskiopuntia of Opuntia deserves generic rank. Its relation to Pereskia is only slight, although in habit it suggests that genus rather than Opuntia. From Opuntia it is easily distinguished by its habit, its broad, persistent leaves, and its seeds.

Genus PERESKIOPSIS Britton & Rose, gen. nov.

Trees and shrubs similar in habit and foliage to *Pereskia,* old stems forming a solid woody cylinder covered with bark and resembling ordinary dicotyledonous stems; areoles circular, spine-bearing or sometimes spineless, also bearing hairs and glochids; flowers similar to those of *Opuntia;* ovary inferior, sessile, leafy, rarely leafless; fruit red; seeds few, covered with matted hairs.

Common in hedges and thickets of Mexico and Guatemala.

Eleven species are known, of which 9 are now in cultivation in Washington and New York. Two of these species were described as early as 1828 as *Pereskias,* and here they remained with two later described species until in 1898 Dr. A. Weber transferred them to Opuntia.

Type species: *Opuntia brandegeei* Schum.

1. PERESKIOPSIS AQUIOSA (Weber) Britton & Rose

Opuntia aquiosa Weber, Bull. Mus. Hist. Nat. Paris 4: 165. 1898.

Type locality: Cultivated at Guadalajara, Mexico.

Distribution: Jalisco, Mexico.

2. PERESKIOPSIS BRANDEGEEI (Schum.) Britton & Rose

Opuntia brandegeei Schum. Gesam. Kacteen 653. 1901.

Type locality: Near Cape San Lucas, Lower California.

Distribution: Southern Lower California.

3. PERESKIOPSIS CHAPISTLE (Gosselin) Britton & Rose

Opuntia chapistle Gosselin, Bull. Mus. Nat. Hist. Paris 10: 388. 1904.

Type locality: Oaxaca, Mexico.

Distribution: Oaxaca, Mexico.

Plate XLIII, reproduction of a photograph taken by Dr. D. T. McDougal, near Oaxaca City, Mexico.

4. PERESKIOPSIS DEGUETII (Weber) Britton & Rose

Opuntia deguetii WEBER, Bull. Mus. Hist. Nat. Paris 4: 166. 1898.

Type locality: Mexico.
Distribution: Jalisco, Mexico.

5. PERESKIOPSIS KELLERMANII Rose, sp. nov.

Stems glabrous, herbaceous, weak and clambering over shrubs, about 2 cm. in diameter; second year's branches with cherry-colored bark; old stem spineless (?); young branches spineless or with a single short spine; glochids numerous, brownish; leaves glabrous, orbicular to ovate, 3 cm. long by 2 to 2.5 cm. broad, acute; flowers not seen; fruit red, glabrous, leafy, 6 cm. long; seeds covered with matted hairs.

Collected by W. A. Kellerman at Trapichite, Guatemala, January 1, 1907 (no. 6025).

Type in U. S. National Museum, no. 575,464.

6. PERESKIOPSIS OPUNTIAEFLORA (DC.) Britton & Rose

Pereskia opuntiaeflora DC. Prod. 3: 475. 1828.
Opuntia golziana SCHUM. Gesam. Kacteen 694. 1901.

Type locality: Mexico.
Distribution: Mexico.
Illustration: Mem. Mus. Hist. Nat. 17: *pl. 19*.

7. PERESKIOPSIS PITITACHE (Karw.) Britton & Rose

Pereskia pititache KARW. in Pfeiff. Enum. 176. 1837.
Opuntia pititache WEBER in Bois, Dict. Hortic. 899. 1899.

Type locality: Mexico.
Distribution: Mexico.

8. PERESKIOPSIS PORTERI (Brandegee) Britton & Rose

Opuntia porteri BRANDEGEE; Weber in Bois, Dict. Hortic. 899. 1899.

Type locality: Sinaloa, Mexico.
Distribution: West coast of Mexico.

9. PERESKIOPSIS ROTUNDIFOLIA (DC.) Britton & Rose

Pereskia rotundifolia DC. Prod. 3:475. 1828.
Opuntia rotundifolia Schum. Gesam. Kacteen 652. 1901.

Type locality: Mexico.
Distribution: Mexico.
Illustration: Mem. Mus. Hist. Nat. 17; *pl. 20;* Schum. Gesam. Kacteen *f. 99.*

10. PERESKIOPSIS SPATHULATA (Otto) Britton & Rose

Pereskia spathulata Otto, Pfeiff. Enum. 176. 1837.
Opuntia spathulata Weber, Bull. Mus. Hist. Nat. Paris 4:165. 1898.

Type locality: Mexico.
Distribution: Mexico.

11. PERESKIOPSIS VELUTINA Rose, sp. nov.

Stems weak and spreading, forming compact bushes 9 to 12 cm. high or sometimes higher; old stems with cherry-brown bark; young branches green, borne nearly at right angles to the old stem, velvety-pubescent; areoles bearing long white hairs, several short spines, and some bristles; leaves broadly ovate, 2 to 4 cm. long by 1.5 to 2.5 cm. broad, mucronate, acute, dull green, more or less velvety-pubescent on both surfaces, or when very young brighter green and quite glabrous, narrowly lanceolate; flowers generally (if not always) sessile on the second year's stems; ovary obovate to oblong in outline, pubescent, bearing large leaves and areoles similar to those of the stem; leaves spreading or ascending and persisting after the flower falls; flower bud (above the ovary) 2 to 3 cm. long, acute, the outer sepals green or deep red tinged with yellow; petals bright yellow.

Collected by J. N. Rose in hedges about the city of Queretaro, August 20, 1906 (no. 11,149); living collection: 06.1054.

This plant is called by the natives "Nopaleta" and "Colo de diablo."

Type in U. S. National Museum, no. 453,934.

Plate XLIV shows a greenhouse specimen.

PERESKIOPSIS CHAPISTLE (Gosseiin) Britton & Rose

PERESKIOPSIS VELUTINA Rose

TWO NEW FERNS OF THE GENUS LINDSAEA

By LUCIEN M. UNDERWOOD AND WILLIAM R. MAXON

The two ferns of the genus *Lindsaea* here to be described, one from Colombia, the other from Cuba, we regard as very distinct and readily recognizable; otherwise we should hesitate to add to the list of names in a genus so thoroughly in need of careful revision.

LINDSAEA PITTIERI Underwood & Maxon, sp. nov.

Apparently mature plants 10 to 11.5 cm. high. Rhizome very short-creeping, with close-set, bright brown, glistening, narrow, lanceolate-attenuate scales about 1 mm. in length; fronds subcespitose, conform, erect, simply pinnate, very dark green; stipes 2.5 to 3 cm. long, relatively stout (about 0.75 mm. in diameter), castaneous, smooth, lustrous, convex dorsally, the upper surface concave with two narrow greenish-yellow wings extending to the quadrangular rachis; lamina exactly lanceolate, 8 to 9 cm. long, with about 10 pairs of approximate or somewhat spaced pinnæ and a hastate unequal terminal segment (3 cm. long); pinnæ nearly sessile, spreading, the lowermost pair lunate and strongly deflexed, the lower margin nearly parallel to the rachis, the other pinnæ subopposite and nearly of equal size, 11 to 13 mm. long, 5 mm. maximum width, decidedly lunulate, spreading or somewhat deflexed, at the base sharply cuneate, the inner margin (length 5 mm.) slightly concave and parallel to the rachis, the superior margin continuously rounded, the lower decurved; venation free, oblique, repeatedly dichotomous, ultimate veinlets 10; sori continuous, following the deeply curved upper margin from the base above around the subobtuse apex; indusium narrow (less than 0.5 mm. broad), one-third or less as wide as the opposed indusiform margin, at maturity the sporangia distant about 1 mm. from the sharply and irregularly erose margin.

Type in the U. S. National Museum, sheet no. 530,720, collected at an altitude of 30 to 100 meters near Córdoba, in the Dagua Valley, Pacific coastal zone, State of Cauca, Colombia, in December, 1905, by H. Pittier, no. 533.

L. Pittieri probably finds its nearest ally in *L. Leprieurii* Hook.,[1] a French Guianan species erroneously referred to *L. falcata* by

[1] Sp. Fil. 1: 208, *pl. 62. D.* 1846.

Christensen. It is similar in its pinnate condition, enlarged hastate terminal segment, and in having the narrow indusium at a considerable distance from the margin. It differs specifically, however, in having its subfasciculate fronds borne upon a stout short-creeping rhizome, in having the pinnæ decidedly rounded at the apex (instead of acuminate), and in its much smaller fronds, both fronds and pinnæ being about one-half the size of those of *L. Leprieurii.*

LINDSAEA CUBENSIS Underwood & Maxon, sp. nov.

A slender cespitose plant rising from a short, slender, creeping rhizome with spreading brown scales 1 mm. or less in length. Fronds light green, delicate, simply pinnate, the sterile spreading in a cluster, 5 to 6 cm. long, about 8 to 10-jugate, the fertile taller, erect, attaining 20 to 30 cm., 10 to 25-jugate; stipes sulcate, as long as the lamina in the fertile fronds, shorter in the sterile, slender, stramineous, darkened near the base, smooth throughout; pinnæ of the fertile fronds short-stalked, mostly lunate, the apices obtuse, the lower margins straight or somewhat decurved, or the lowest pinnæ sometimes obliquely and broadly cuneate, these 8 to 11 mm. long by 5 to 7 mm. wide, the succeeding pairs very gradually smaller, smooth, the outer margin denticulate; veins free, about 4 or 5 times dichotomously forked; sori terminal on the veins, forming a continuous band about 0.5 mm. distant from the margin; indusia subcontinuous, pale, the margins irregularly and often deeply erose.

Type in the herbarium of the New York Botanical Garden; collected in Cuba by Charles Wright, no. 3947. This number is also in the U. S. National Museum. Other Cuban specimens are:

PINAR DEL RIO:

Herradura, *Shafer,* 427;
El Guama, *Palmer and Riley,* 287;
Mountains north of San Diego de los Baños, *Palmer and Riley,* 550.

ISLE OF PINES:

Managua, *Palmer and Riley,* 1060;
Nueva Gerona, *Palmer and Riley,* 1027; *Curtiss.*

Among American species of the genus *L. cubensis* is unique in its slight texture and delicate stramineous vascular parts, in which particulars, as well as in general appearance, it bears a superficial resemblance to the East Indian *L. cultrata.* The difform fronds are characteristic.

FIVE NEW RECENT CRINOIDS FROM THE NORTH PACIFIC OCEAN

By AUSTIN HOBART CLARK

Assistant, Bureau of Fisheries

In 1900 the United States Fisheries steamer *Albatross* made a small collection of about three hundred specimens of crinoids in the waters about southern Japan, mostly in the vicinity of Sagami Bay; she also obtained crinoids in a single haul off the coast of Kamchatka. The material was originally assigned to Prof. Hubert Lyman Clark, of the Museum of Comparative Zoölogy at Cambridge, Mass., for study; but, owing to pressure of other work, he has been unable to turn his attention to it. After my return from Japan, he most kindly turned over to me the entire 1900 collection, to work up in connection with the much larger one made in 1906.

Although comparatively small, this 1900 collection has many points of interest. Fourteen species are represented, three of which were not found in 1906. A new *Bathycrinus,* of quite a different type from *B. pacificus,* was secured off Kamchatka; a new *Zygometra,* of which the 1906 collection contains a single example so poor I did not consider it wise to describe it, is represented by a number of specimens. There are also three new species of *Antedon,* two of which are represented by a good series. These last all belong to a small group of the genus, represented by *Antedon nana* and *A. briseis,* which appears to be characteristic of the region from Australia and the Tonga Islands northward to Japan, corresponding to the *A. hagenii* group, so abundant in the Caribbean Sea. Owing to their small size and brittle nature it is somewhat difficult to obtain specimens of these species, the smallest of all the Antedonidæ, in good enough shape to justify description. Besides those already described, there are a number of others which are known to me from the study of specimens.

BATHYCRINUS COMPLANATUS, sp. nov.

This new species of *Bathycrinus* represents in the north Pacific *B. carpenterii* (Danielssen and Koren) of the north Atlantic, to which it is closely allied. It is represented in the collection by fourteen calyces, eighteen roots with more or less of the stem attached, and many stem fragments of various lengths, all from *Albatross* Station No. 3783, approximately 40 miles S. S. W. ½ W.

of Southeast Cape, Copper Island, Commander Group; depth 1567 fathoms, with a bottom of gray volcanic sand and green mud. The bottom temperature was not recorded.

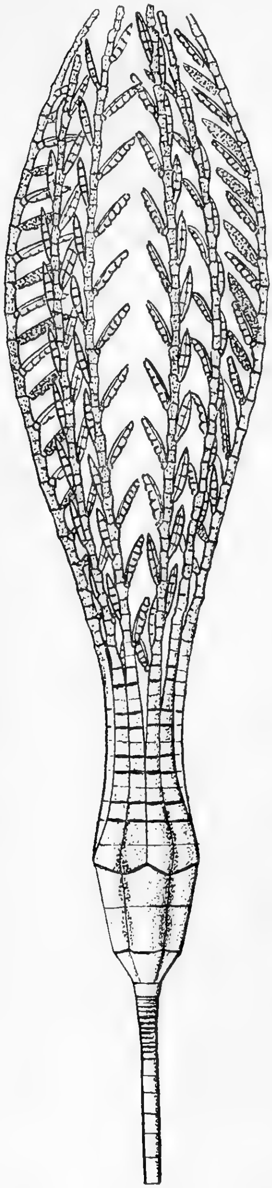


FIG. 123.—*Bathycrinus complanatus*, sp. nov.

Basals united into a smooth ring, slightly wider above than below, the superior diameter of which is equal to about twice the height; radial cup funnel-shaped, about once and a half as broad at its upper end as high, the dorsal surface of the radials rounded, but low, so that the dorsal aspect of the cup is almost circular; first costals long, trapezoidal, longer than the radials; axillaries pentagonal, slightly wider than high, the anterior angle much more produced than in *B. carpenterii;* both the costals are low and rounded, and there is no indication of a median keel.

First brachials wedge-shaped, wider (usually much wider) than long; second brachials slightly longer and more oblong; following brachials approximately square, gradually becoming elongated toward the tips of the arms; the brachials up to the sixteenth or seventeenth are deep, and are strongly flattened laterally, exhibiting that character called "wall-sidedness" by Dr. Carpenter to a very marked degree. The first two brachials, the fourth and fifth, and the seventh and eighth are closely united by trifascial articulation, after which the ninth and twelfth are the only single brachials, all the others being united in pairs by the alternation of bi- and trifascial articulations; in other words, the third, sixth, ninth, and twelfth brachials are single segments, all the others being united in pairs.

The first pinnule is usually on the twelfth brachial, but may occur as early as the tenth.

The stem appears to contain about one hundred segments, of which the first twelve or fifteen are wider than high, most of them very short and discoidal, those immediately below the basals being slightly wider than the somewhat thicker ones on which they rest; the columnars increase in length rapidly at first, then more gradually, reaching a maximum of somewhat over 3 mm. in length about the middle of the stem, after which the length gradually decreases again until near the bottom, the last ten or twelve columnars being long and very stout, with greatly expanded ends, ending in a rather large branching root.

The largest specimen measures 60 mm. from the basals to the tips of the arms, the stem being 225 mm. long; the smallest crown is about 30 mm. long. The color in spirits is delicate brownish or dull yellowish white, the disk dark brown.

Type.—Catalogue No. 22,662, U. S. N. M., from the locality given.

This species comes nearest to *B. carpenterii* (Danielssen and Koren) of the northeast Atlantic; but the stem is composed of very much longer and more slender segments, while the lower brachials, which in *B. carpenterii* are longer than wide, are wider than long, frequently very much so. The arms and pinnules appear to be more slender and delicate than those of *B. carpenterii,* and, lastly, it is about double the size of that species.

ZYGOMETRA KŒHLERI, sp. nov.

Centro-dorsal a flat disk with about twenty marginal cirri; these are short and rather stout with ten to fifteen segments, the first two short, the others longer than wide, somewhat constricted centrally; terminal claw short and curved; opposing spine very small.

Radials just visible, free distally; first costals nearly three times as wide as long, united to the low triangular axillaries by syzygy, both rounded and widely free laterally; ten arms 45 mm. long with sixty-five to eighty brachials, the first seven oblong or slightly wedge-shaped, wider than long, then quadrate and as long as or longer than wide, becoming elongate distally; syzygia in the third, eighth, and twelfth brachials, and distally at intervals of 3 or 4.

First pinnule long and slender with more than twenty segments, the basal three or four wider than long, the remainder elongate; pinnule on the third brachial distinctly (often much) shorter with fewer segments; second pinnule the longest with about twenty-five elongated segments; following pinnules not much shorter, but very much more slender. The anal tube and area about it is heavily plated, but the rest of the disk is almost naked.

Color in life, bright yellow.

Type.—Catalogue No. 22,660, U. S. N. M.; from *Albatross* Station No. 3717, Sagami Bay, Japan; 63-100 fathoms.

The small number of arms, combined with the number of cirrus segments and long second pinnule, readily distinguish this species from all the other forms of *Zygometra.*

ANTEDON ADRESTINE, sp. nov.

Centro-dorsal more or less hemispherical, bearing about forty cirri; these are 10 to 12 mm. long with twelve to fifteen segments, all longer than broad, the proximal two-thirds very much so, and constricted centrally with prominent distal edges; no dorsal spines; terminal claw very small.

Radials just visible; first costals very short, deeply incised by the rhombic axillaries, and with a transversely elongate tubercle on each side; axillaries rhombic, slightly wider than high, with a median keel in the posterior half; ten arms 35 mm. long, with about ninety segments; first brachial very short, incised by the much larger and irregular second brachial; third brachial squarish; following brachials to the eighth oblong or slightly quadrate, wider than long, becoming longer than wide after the twelfth and more elongate distally; syzygia in the third, eighth, and twelfth brachials, and distally at intervals of two. The costals and first brachials are in apposition laterally.

Lower pinnules very long; first pinnule 10 mm. long with 19 long segments; pinnule on the third brachial 10 mm. long with 18 elongated segments; second pinnule slightly longer, with eighteen segments; pinnule on fifth brachial similar; third pinnule 11 mm. long, with twenty elongated segments; pinnule on seventh brachial about 7 mm. long, with about fifteen segments; the eighth and following pinnules bear genital glands; distal pinnules moderately long, very slender, the first segment short, the second and following very long.

Color (in spirits) dirty white, a broad median band of brown on each arm; cirri light brown, white at the articulations; or white, a broad median band of purple on each arm; cirri white.

Type.—Catalogue No. 22,659, U. S. N. M.; from *Albatross* Station No. 3713, off the southern coast of Hondo, Japan; 45-48 fathoms.

The great length of all the lower pinnules, combined with the few cirrus segments, is sufficient to distinguish this species from all the others of the genus *Antedon.*

ANTEDON MINUTA, sp. nov.

Centro-dorsal a low hemisphere, nearly covered with about twenty cirri; these are 5 mm. long, with ten to fifteen segments, all somewhat longer than wide, but the basal not specially longer than the distal; terminal claw rather large; opposing spine small; the articulations of the cirrus segments are prominent, and there is a slight ventral overlap.

Radials visible; first costals oblong, about twice as wide as high; axillaries pentagonal, about as wide as high; ten slender arms, 30 mm. long, with about fifty brachials, long-quadrate, with the first seven roughly squarish; syzygia in the third, eighth, and twelfth brachials, and distally at intervals of two, sometimes three; rays widely separated.

First pinnule 3 mm. long, with about eighteen segments; second pinnule similar, but very slightly longer; the following pinnules become more slender, but do not increase much in length; the two proximal segments of the lower pinnules are enlarged, short, and squarish, the rest somewhat longer than wide, although not especially elongated.

Color (in spirits) pinkish, light brownish, or dull white, with the pinnules brown.

Type.—Catalogue No. 22,661, U. S. N. M.; from *Albatross* Station No. 3725, off the southern coast of Hondo, Japan; 13 fathoms.

This species is more closely related to *Antedon briseis*, from which, however, it is readily distinguishable by having the rays well separated, with no lateral projections, and the lower pinnules composed of short segments. It is also a much smaller species.

ANTEDON ORIENTALIS, sp. nov.

Centro-dorsal low-conical, bearing thirty to fifty cirri, almost none of the pole bare; cirri 13 mm. long, slender, with thirty to thirty-five segments, the proximal two-thirds or more of which are somewhat longer than wide, the distal becoming short; the longer segments are more or less "dice-box shaped," and the distal are strongly carinate dorsally; the two or three apical ("small mature") cirri are 3 or 4 mm. long, very slender and delicate, with twelve to fifteen elongated segments, much constricted centrally; opposing spine well developed.

Radials short, crescentic; first costals short, about three times as wide as long, with lateral dentate processes, and in apposition laterally; axillaries triangular, slightly wider than high, free laterally;

ten arms 45 mm. long; first five brachials roughly oblong, then quadrate, longer than wide, becoming elongated distally; syzygia in the third, eighth, and twelfth brachials, and distally at intervals of three to five (usually four) segments.

First pinnule the longest, about 4 mm. long, with ten segments, the first short, the others much elongated; the following pinnules become shorter, then increase again distally.

Color (in spirits) dull yellow; probably yellow in life.

Type.—Catalogue No. 22,663, U. S. N. M.; from *Albatross* Station No. 4933, off Kagoshima Gulf, Japan; 152 fathoms.

This species comes nearest to *Antedon pumila* Bell, from which it differs in the much greater number of cirrus segments (which are much shorter distally), the much greater length of the cirri, and in having the rays in close lateral apposition, not widely separated and rounded, as in that species. The costals and lower brachials also have more or less tubercular edges, while in *A. pumila* the edges are smooth. Numerous specimens of the latter from Port Jackson were used for comparison.

NEW GENERA OF RECENT FREE CRINOIDS

By AUSTIN HOBART CLARK

Assistant, Bureau of Fisheries

Since the publication of Dr. P. H. Carpenter's great monograph on the recent unstalked crinoids in 1888, the group has received very little attention from systematists, probably because of the rarity of most of the species and the difficulty in getting together representative material of even the more common ones. Dr. Carpenter included in the family Comatulidæ the genera *Thaumatocrinus, Eudiocrinus, Promachocrinus* (including the subsequently differentiated *Decametrocrinus*), *Atelecrinus, Antedon, Comatula* (=*Actinometra*), and *Thiolliericrinus*. All of these, with the exception of *Antedon* and *Comatula,* are comparatively small, strictly homogeneous genera; with them, however, the case is quite different. The genus *Antedon* was divided by Dr. Carpenter into four "series," and all but the first series into two or more "groups," the characters used in the differentiation of the groups and series being (1) the character of the joint between the costals, (2) the number of arms, (3) the number of the distichals, (4) the character of the lower pinnules, (5) the development or absence of covering plates on the ambulacra, and (6) the rounded or "wall-sided" character of the costals and lower brachials. Of all these characters, the first alone is the only one not common to two or more of his series or groups, as diagnosed by him. Taking No. 2, for instance, five of his groups and also several unassigned species are ten-armed; all the rest have more than ten arms. A number of single species have both ten and more than ten arms, as a result of purely individual variation. No. 3 is equally unreliable; some species are both ten-armed and multibrachiate, the latter varieties having the distichals either 2 or 4 (3 + 4); other species, very difficult to differentiate in the ten-armed varieties, become one "bidistichate" and another "tridistichate," according to species in their multibrachiate forms. In regard to No. 4, the lower pinnules of the "Basicurva group" are identical in character with those of the "Spinifera" and "Granulifera" groups, and those of certain of his heterogeneous "Milberti group" with species of the "Palmata" and "Savignii" groups. Taking No. 5, we find covering plates developed in the "Acœla" and "Basicurva" groups among the ten-armed forms, and in the "Spinifera" and "Granulifera" groups among the multibrachiate species; as for No. 6, "wall-sidedness" of the costals and lower brachials, characteristic of the "Basicurva," "Spinifera," and "Granulifera" groups, is equally well marked in species of the "Milberti," "Tenella," and "Palmata" groups, and in species closely allied to *Antedon balanoides.* Since the publication of the *Challenger* report, the family Comatulidæ, as understood by Dr. Carpenter, has been broken up into the families Thaumatocrinidæ (*Thaumatocrinus*), Antedonidæ (including *Eudiocrinus, Antedon,* and *Thiollieriericrinus*), Atelecrinidæ (*Atelecrinus*), Actinometridæ (*Comatula*), and Decametrocrinidæ (*Promachocrinus* and *Decametrocrinus*). The family Decametrocrinidæ appears to be somewhat unnatural. *Decametrocrinus* is most nearly related to *Eudiocrinus,* and it is doubtful if single arms from species of the two genera could be differentiated; *Decametrocrinus* is clearly a meristic variation from a *Eudiocrinus* type. The two genera agree in having the disk black, the perisome extending far up on the arms, in having single undivided arms, and perfectly smooth cirri with elongated segments; the first two characters do not occur in any other genera of free crinoids, while a detailed study of the cirri will probably prove them to be quite as characteristic. Another point is that the ambulacra in *Eudiocrinus* and *Decametrocrinus* do not divide upon the disk; in the former there are five ambulacra running from the mouth to the arms, and in the latter ten, arranged in five pairs. Taking these points into consideration, it appears most logical to unite *Decametrocrinus* and *Eudiocrinus,* making of them the family Eudiocrinidæ, from which combination *Promachocrinus* is omitted. I only know *Promachocrinus* from what has been written of the genus, having had no opportunity of examining specimens; and it therefore seems best not to say anything about it for the present, more particularly as we shall soon hear something in regard to it from one of the foremost authorities on the recent crinoids. Attention should here be called to the researches of Mr. Frank Springer on *Uintacrinus* and its probable relationship with the genus *Comatula.*

Turning our attention again to the genus *Antedon,* we find that it has been revised by Hartlaub in 1895, and by Minckert in 1905. The former divided *Antedon* into groups with, and without, plated ambulacra, but otherwise followed Carpenter. Minckert, in his instructive work on the arm regeneration in the comatulids, uses Carpenter's groups, but proposes another group, the "Brevipinna group," for species with plated ambulacra, and variable (2 or 4 (3 + 4) or both) distichal series. Both authors take Carpenter's groups as homogeneous units, which in many cases they are not;

for instance, the "Basicurva group" contains species both with and without plated ambulacra; the "Milberti group" contains two species really belonging to the "Tenella group," and others only remotely related to *Antedon milberti,* etc. The genera here proposed are capable of exact and diagnostic definition, and occupy definite and characteristic geographical areas, as well as bathymetrical and thermal altitudes, which is the case with but one or two of the units heretofore used in the classification of the finer divisions of the old genus *Antedon.*

No attempt is made in this paper to discuss the relationships of the fossil Antedonidæ and Actinometridæ, a study of these forms having been rendered impossible through lack of material; I hope, however, to be able to consider them later. In the list of species at the end of each genus names of species which have not been described accurately enough to admit of generic determination, or names regarded as synonyms, are omitted; but a synonymy of all the species has been worked out, and will probably be published in the near future.

Key to the Genera Described

A. Pinnule ambulacra without covering plates.

a. Costals united by syzygy.................................(1) *Zygometra*

aa. Costals united by bifascial articulation.

b. A pinnule on the 4th (epizygal) brachial.

c. Lower pinnules stout and prismatic, subequal in length; costals and lower brachials sharply "wall-sided."

d. First pinnule as large as or larger than the second or third; brachials long, triangular or quadrate; first two brachials not enlarged; always light yellow in color. (2) *Nanometra*

dd. First pinnule smaller than those following; brachials very short, discoidal; first two brachials much enlarged; deep purple or reddish brown in color, usually blotched with yellow..............(3) *Tropiometra*

cc. Lower pinnules greatly elongated, slender, and flagellate, the first with very numerous short and broad joints; costals rounded, well separated.

d. All the greatly elongated lower pinnules are composed of short and broad joints, and are more or less serrate toward the tip; centrodorsal hemispherical with very numerous cirri; cirri long, the proximal segments elongate, the distal short, sharply carinate or spiny always with an opposing spine; terminal claw curved, moderate in length or short; brachials quadrate or triangular; yellow ....(4) *Heliometra*

dd. All but the first of the elongated lower pinnules are composed of greatly elongated joints and are smooth distally; centro-dorsal discoidal with numerous cirri, which are composed of greatly elongated smooth joints; terminal claw very long and nearly straight; no opposing spine; middle and distal arm joints discoidal; brown or grayish.........(5) *Thysanometra*

ccc. One or more of the lower pinnules elongated; but all the lower pinnules are slender and have elongated, smooth, cylindrical joints.

d. The first joint of the elongated proximal pinnules is always short; distal pinnules cylindrical, very slender, not elongated; centro-dorsal hemispherical or discoidal, the cirri without definite arrangement; some or all of the cirrus segments markedly "dice-box shaped." (6) *Antedon* de Fréminville

dd. All the pinnules greatly elongated, the first joint as well as the others very long; centro-dorsal conical or long columnar, divided by five broad interradial ridges or planes into areas, each with definite vertical rows of cirrus sockets; cirrus segments cylindrical or flattened, never "dice-box shaped."

e. Costals and lower brachials smooth, well-separated, and rounded; cirri smooth with all the joints elongated, arranged in 3, 4 or 5 rows in each radial area. (7) *Psathyrometra*

ee. Costals and lower brachials spiny, sharply "wall-sided;" cirri with much elongated joints proximally, very short and spiny joints distally, arranged in 2 rows in each radial area....................(8) *Zenometra*

cccc. Lower pinnules cylindrical, one or more enlarged, very stout, styliform, or more or less flagellate.

d. Cirri without definite arrangement; centro-dorsal discoidal.

e. Cirri long with 50-70 short segments, bearing dorsal spines distally; pinnule of second brachial greatly elongated and flagellate, the following pinnules very short; costals widely free laterally, and rounded. (9) *Pontiometra*

ee. Cirri moderate or short, with not more than 40 segments; one or more of the lower pinnules very stout, stiff, elongate, styliform or more or less flagellate, with cylindrical segments; following pinnules decrease gradually in length; outer surface of costals (also distichals and palmars when present) and lower brachials rounded, never carinate, convex dorsoventrally, imparting a swollen appearance to the segments, usually more or less tubercular. (10) *Himerometra*

dd. Cirri in 10 vertical rows, on a long conical centro-dorsal. (18) *Adelometra*

bb. No pinnule on the 4th (epizygal) brachial.

c. Centro-dorsal discoidal, the short cirri in two or three irregular marginal rows; costals and lower brachials not

tubercular, the former well-separated laterally.
(11) *Cyllometra*

cc. Centro-dorsal conical, the elongate and slender cirri in more or less definite vertical rows; costals and lower brachials strongly tubercular, in close apposition, and sharply "wall-sided." ....(12) *Perometra*

AA. Pinnule ambulacra plated.

a. Pinnules stout and prismatic, closely set; costals (also distichals and palmars when present) and lower brachials sharply "wall-sided."

b. Distal pinnules extend several millimeters beyond tip of arm, which is sharply recurved; first pinnule of the same character as the following, but much smaller; cirri very long with 80 to 130 segments........(13) *Ptilometra*

bb. Distal pinnules very short, not extending beyond tip of arm, which is not incurved.

c. First pinnule much enlarged, composed of a few large, stout segments; genital pinnules not differentiated; cirri long, slender, with 25 to 90 segments, the distal always spiny ....(14) *Thalassometra*

cc. First pinnule more slender than the following, longer, composed of a large number of small joints; genital pinnules more or less expanded; cirri short and stout, with less than 30 segments without dorsal spines.
(15) *Charitometra*

aa. Pinnules prismatic; costals deep, with concave sides and a prominent latero-posterior thin flange-like margin; genital pinnules much expanded; cirri short, stout, and smooth.
(16) *Pœcilometra*

aaa. Pinnules slender and cylindrical, well separated and thorn-like; costals rounded; cirri distally spiny...(17) *Calometra*

1. ZYGOMETRA, gen. nov.

Centro-dorsal discoidal, bearing one to three rows of marginal cirri; cirri very variable, but always stout, with 15 to 50 segments, with or without dorsal spines; the segments are, however, always short (almost always broader than long), and very uniform in size; disk always plated, but pinnule ambulacra naked; costals united by syzygy, always well rounded, well separated laterally, never carinate; ten to ninety or more arms, distichals 4 $(3+4)$ (almost never 2), the subsequent series either 2 or 4 $(3+4)$; lower pinnules more or less elongate (but not markedly so), the basal segments often somewhat carinate; distal edges of costals and brachials often everted or overlapping; brachials always wider than long.

Color in life yellow, brown, purple, or red, usually more or less definitely banded.

Type of the genus.—Antedon microdiscus Bell, 1884.

Zygometra corresponds to Dr. Carpenter's "Elegans group" or series 1 of *Antedon,* and is composed of species occurring from Australia northward to southern Japan. In regard to this genus the question at once arises as to whether the generic name *Hyponome,* proposed by Lovén, should not be used. *Hyponome* was founded on a detached visceral mass, probably of *Antedon microdiscus,* which was considered by Professor Lovén to be a recent cystidean, and described as such. Now the characters given for *Hyponome sarsii* do not permit us to refer it to any species of *Zygometra* with any degree of certainty; in other words, *Hyponome* is a genus with a non-recognizable type, and therefore has no standing.

The following described species are referable to *Zygometra;* I have examined an additional species from Japan:

Zygometra elegans (Bell)
" *hartlaubi* (A. H. Clark)
" *kœhleri* A. H. Clark

Zygometra microdiscus (Bell)
" *multiradiata* (P. H. Carpenter)
" *rubroflava* (A. H. Clark)

2. NANOMETRA, gen. nov.

Centro-dorsal hemispherical, bearing 15 to 25 rather slender cirri with 25 to 30 segments, very uniform, never much longer than wide, the distal sometimes more or less carinate; disk and pinnule ambulacra not plated; costals united by bifascial articulation, short and broad, in lateral apposition, with sharply flattened sides (*i. e.,* "wall-sided"); the first two or three brachials also have sharply flattened sides; ten arms, the brachials quadrate, sometimes elongate; the third and fourth brachials united by syzygy (usually); a second syzygy occurs between brachials 9 and 10 to brachials 13 and 14, and syzygia occur distally with 2 to 8 bifascial articulations intervening; lower pinnules stout, more or less carinate and prismatic, but not elongate; middle and distal pinnules slender, more or less carinate or prismatic, the first two segments short, more or less expanded, the others elongate.

Color in life, yellow.

Type of the genus.—Antedon minor A. H. Clark, 1907.

Nanometra includes those species of Dr. Carpenter's "Basicurva group" which differ markedly from all the others in entirely lacking the characteristic plating of the disk and ambulacra. They are all small species, inhabiting warm and comparatively shallow water, and are found from the Arafura and Australian seas northward to southern Japan.

The following are the described species of the genus:

Nanometra denticulata (P. H. Carpenter)
" *minckerti* A. H. Clark[1]
Nanometra pusilla (P. H. Carpenter)
" *wilsoni* (Bell)

3. TROPIOMETRA, gen. nov.

Centro-dorsal discoidal, bearing 20 to 30 marginal cirri in one more or less irregular row; cirri stout, short, with 20 to 35 segments, all wider than long, perfectly smooth, the opposing spine on the penultimate absent or but faintly indicated; terminal claw small and short; disk and ambulacra naked; costals broad and nearly flat, united by bifascial articulation, in close apposition laterally, and more or less "wall-sided;" always ten arms; first brachial oblong, and rather disproportionately large; second brachial wedge-shaped, rather larger than the first; first two brachials in close lateral contact with those on adjacent rays, and more or less flattened laterally; following brachials very short, oblong, discoidal, or very slightly quadrate, the arms with or without a median keel; third and fourth brachials united by syzygy; other syzygies usually between the ninth and tenth and fourteenth and fifteenth, or approximately in those positions; distally syzygia occur with intervals of from 2 to 9 bifascial articulations; lower pinnules subequal, stout, prismatic, sharply carinate, with 20 to 25 short segments, mostly broader than long, flattened externally; distal pinnules very slender, elongate, usually non-carinate.

Color (in spirits) purple or purple-brown, often more or less spotted or blotched with yellow; sometimes yellow, or reddish purple and yellow; rarely white.

Type of the genus.—Comatula carinata Lamarck, 1816.

This genus is equivalent to a part of Dr. Carpenter's "Milberti group," and contains four species, their united ranges including, so far as can be judged, all tropical seas, the Red Sea, northward to Japan, and southward to Chile and the Cape of Good Hope.

The known species referable to this genus are:

Tropiometra afra (Hartlaub)
" *carinata* (Lamarck)[2]
Tropiometra braziliensis (Rathbun)
" *macrodiscus* (Hara)

[1] *Nanometra minckerti,* new name for *Antedon minor* A. H. Clark, preoccupied. I take great pleasure in dedicating this interesting species to Mr. Wilhelm Minckert, in recognition of his excellent work on the unstalked crinoids.

[2] *Antedon capensis* Bell, described in the "Basicurva group," is a synonym of this species. I have compared specimens identified by Professor Bell with others from Zanzibar and find them identical.

4. HELIOMETRA, gen. nov.

Centro-dorsal hemispherical, bearing very numerous cirri without definite arrangement, well distributed over the surface, but the pole always free; cirri long, moderately stout, with numerous (30 to 80, usually 40 to 60) segments, the proximal somewhat longer than wide, the distal short, and provided with more or less prominent dorsal spines; disk and ambulacra unplated; costals united by bifascial articulation, rounded, never carinate, usually well separated; arms always ten in number; brachials very numerous, always triangular or more or less quadrate, more or less overlapping, never carinate nor laterally compressed; syzygial joints between brachials 3 and 4, 9 and 10, and 14 and 15, or 16 and 17 (irregularly between 15 and 16); distally 2 to 6 bifascially articulated joints (most commonly 3 or 4) intervene between successive syzygia; proximal pinnules greatly elongated and flagellate, the first and second always, and usually the third and fourth, composed of very numerous joints which are wider than long, at least in the basal half; the distal portion of the lower pinnules is always more or less serrate or combed; distal pinnules slender and elongate, set closely together, the first two joints expanded and trapezoidal, the others elongated.

Color in life yellow, in one species more or less blotched with white.

Type of the genus.—*Alecto eschrichtii* J. Müller, 1841.

This genus corresponds to the "Eschrichti group" of Dr. Carpenter, and contains at present eighteen described species. In addition to these I have examined some undescribed forms from the neighborhood of Shanghai. The distribution as at present known is: Arctic and Antarctic seas, northern and southern Atlantic, entire American coast of the Pacific, Bering Sea, Sea of Okhotsk, Sea of Japan, and the coasts of the western Pacific, south at least to Shanghai.

The species of *Heliometra,* taken as a whole, form a remarkably homogeneous aggregation, the differential specific characters being, when compared with those of the other genera of recent free crinoids, very slight; for instance, most of the well-known species of *Himerometra,* to say nothing of the extraordinary *Cyllometra manca,* exhibit more individual than *Heliometra* does generic variation. The regular distribution of the syzygia is noteworthy, forming as it does in several species a reliable specific character. No other genus has the syzygia thus regularly placed, although an approach to it is noticeable in *Antedon.*

The following are the described species of the genus:

Heliometra antarctica (P. H. Carpenter)
" *asperrima* (A. H. Clark)
" *brachymera* (A. H. Clark)
" *clio* (A. H. Clark)
" *eschrichtii* (J. Müller)
" *glabra* (A. H. Clark)[1]
" *hondoensis* (A. H. Clark)
" *inexpectata* (A. H. Clark)
" *juvenalis* A. H. Clark
" *laodice* (A. H. Clark)
Heliometra magellanica (Bell)
" *mariæ* (A. H. Clark)
" *maxima* (A. H. Clark)
" *perplexa* (A. H. Clark)
" *quadrata* (P. H. Carpenter)
" *rathbuni* (A. H. Clark)
" *rhomboidea* (P. H. Carpenter)
" *serratissima* (A. H. Clark)
" *tanneri* (Hartlaub)

5. THYSANOMETRA, gen. nov.

Centro-dorsal discoidal, bearing 50 to 70 marginal cirri in several marginal rows; cirri slender and very smooth, with 15 to 20 greatly elongated segments; no trace of dorsal spines; no opposing spine; terminal claw very long and nearly straight; disk and ambulacra naked; costals rounded, well separated, never carinate; ten arms, the brachials mostly oblong, but sometimes slightly quadrate in the anterior third of the arm; third and fourth, ninth and tenth, and fourteenth and fifteenth brachials united by syzygy; syzygia distally with usually 3 bifascial articulations intervening; lower pinnules greatly elongate and flagellate, the first composed of very numerous short and broad segments, the others of segments all but the basal 3 or 4 of which are greatly elongated; distal pinnules very slender, with greatly elongated segments.

Color in life grayish brown, the skeleton and cirri nearly white.

Type of the genus.—Antedon tenelloides A. H. Clark, 1907.

This genus contains a single peculiar species, known only from southern Japan. It is:

Thysanometra tenelloides (A. H. Clark)

6. ANTEDON de Fréminville 1811

Centro-dorsal hemispherical, rarely more or less discoidal, bearing from 10 to 15 to nearly 60 cirri, the pole always free; cirri of variable length, composed of from 10 to 50 segments, all of which are usually longer than wide (frequently very much so); although the last few are sometimes comparatively short, there is never any great difference between the longest and the shortest segments; cirrus segments

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[1] *Heliometra glabra,* new name for *Antedon australis* P. H. Carpenter, 1888; not *Antedon australis* P. H. Carpenter, 1882.

always more or less constricted centrally, the articulations expanded (*i. e.*, "dice-box shaped"), at least in the proximal half of the cirri; cirri smooth, or with more or less developed dorsal spines; terminal claw (on penultimate segment) always prominent, at least on some of the cirri; disk and ambulacra naked, rarely with small scattered calcareous granules on the former; costals united by bifascial articulation, thin, broad, not very convex, often carinate, normally in apposition laterally when the arms are closed, sometimes distinctly "wall-sided" (by individual, not specific, variation); ten arms—abnormal specimens of certain species occasionally have more, in which case the distichals are 2 or 4 (3 + 4)—long and slender, evenly tapering, the brachials triangular, almost always longer than wide (after the third syzygial joint), becoming greatly elongated and often "dice-box shaped" distally; brachials rounded, never carinate nor overlapping, but the distal edge is sometimes fringed with spines; surface of costals and lower brachials sometimes more or less covered with closely set spines; syzygia between brachials 3 and 4, 9 and 10, and usually 14 and 15, the last somewhat variable, and distally at intervals of 2 to 6 (usually 2 to 4) articulations; the syzygia, as a rule, regularly distributed in each species; pinnules with smooth segments, one or more of the proximal pinnules always elongated and flagellate, composed of elongated segments, but the first segment always short; distal pinnules with the first segment very short, the others greatly elongated, more or less swollen at the joints.

Color in life variable, purple, rose, red, orange, yellow, green or brown, usually more or less mottled or banded.

Type of the genus.—*Antedon gorgonia* de Fréminville, 1811 = *Asterias bifida* Pennant, 1777 = *Comatula mediterranea* Lamarck, 1816 = *Comatula fimbriata* Miller, 1821, etc.

The genus *Antedon,* as here restricted, is practically equivalent to the "Tenella group" of Dr. Carpenter. Two species, *Antedon pumila* Bell and *Antedon parvicirra,* obviously belong with the *Antedon bifida* type, and it is difficult to see why Dr. Carpenter placed them, as he did, with *Himerometra milberti.* The shape and proportions of the brachials, cirri, and pinnules, and the regular disposition of the syzygia at once proclaim their relationship with the small tropical forms of the genus *Antedon,* such as *Antedon nana, A. briseis,* and *A. minuta.* *Antedon* is practically cosmopolitan, and occurs from the littoral region down at least to 2,900 fathoms. The species of this genus are peculiarly difficult of determination, as they are the most brittle of all the Antedonidæ, and it is very hard to secure them in recognizable shape; thus it is that, although I have examined many specimens from the American shores of the Pacific, and a number from the Bering Sea and Asiatic coasts, only a few are in a condition admitting of more than a generic diagnosis.

The following species are referable to *Antedon* as here restricted:

Antedon abyssicola P. H. Carpenter
" *abyssorum* P. H. Carpenter
" *adeonæ* (Lamarck)
" *adrestine* A. H. Clark
" *alternata* P. H. Carpenter
" *angustipinna* P. H. Carpenter
" *arctica* A. H. Clark
" *bifida* (Pennant)
" *briscis* A. H. Clark
" *carpenteri* Bell
" *challengeri* A. H. Clark[1]
" *ciliata* A. H. Clark
" *dentata* (Say)
" *dübeni* Böhlsche
" *exigua* P. H. Carpenter
" *hirsuta* P. H. Carpenter
" *hupferi* Hartlaub
" *isis* A. H. Clark

Antedon japonica Hartlaub
" *lævis* P. H. Carpenter
" *longipinna* P. H. Carpenter
" *minuta* A. H. Clark
" *nana* Hartlaub
" *orientalis* A. H. Clark
" *parvicirra* P. H. Carpenter
" *parvula* Hartlaub
" *phalangium* (J. Müller)
" *prolixa* Sladen
" *psyche* A. H. Clark
" *pumila* Bell
" *remota* P. H. Carpenter
" *serrata* A. H. Clark
" *serripinna* P. H. Carpenter
" *stella*[2] A. H. Clark
" *tenella* (Retzius)
" *tenuicirra* P. H. Carpenter

7. PSATHYROMETRA, gen. nov.

Centro-dorsal long and conical, divided by five interradial ridges into areas containing 3 to 5 parallel vertical rows of cirrus sockets; cirri with 30 to 40 elongated, compressed, smooth segments, the longest three or four times as long as wide, gradually decreasing in length distally; terminal spines very small; disk and ambulacra naked; costals well separated, always rounded; ten arms, strongly convex dorsally, deep, but not carinate nor compressed; pinnules all much elongated, the first joint as well as the others greatly elongated.

Color in life light pinkish to deep purple.

Type of the genus.—*Antedon fragilis* A. H. Clark, 1907.

This genus occurs in the north Pacific Ocean, from Panama northward, and in the Sea of Japan and the Bering Sea. None of the three species were known to Dr. Carpenter. The species included in this genus are:

Psathyrometra bigradata (Hartlaub)
Psathyrometra erythrizon (A. H. Clark)
Psathyrometra fragilis (A. H. Clark)

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[1] *Antedon challengeri,* new name for *Antedon lineata* P. H. Carpenter, 1888; not *Antedon lineatus* Pomel, 1887.

[2] *Antedon stella,* new name for *Antedon tenuis* A. H. Clark, 1907; not *Antedon tenuis* P. H. Carpenter, 1887.

8. ZENOMETRA, gen. nov.

Centro-dorsal long, conical or columnar, divided by five interradial ridges, often very high, each radial area containing two vertical rows of cirrus sockets; cirri long, with about 50 segments, the basal half of which are greatly elongated, the distal very short, bearing prominent dorsal spines; disk and ambulacra naked; ten arms; costals and lower brachials in close apposition and strongly "wall-sided," more or less covered with small spines; pinnules all much elongated, the first joint, as well as the others, greatly elongated.

Color in life not recorded; in spirits, pinkish.

Type of the genus.—*Antedon columnaris* P. H. Carpenter, 1881.

Zenometra is most closely related to the Pacific *Psathyrometra,* which it represents in the Caribbean Sea. One species only has been described, but I have examined specimens of one or two others from the West Indies. The only described species of the genus is:

Zenometra columnaris (P. H. Carpenter)

9. PONTIOMETRA, gen. nov.

Centro-dorsal discoidal, bearing about 40 cirri in two or three marginal rows; cirri long, with 50 to 70 very uniform short segments, the distal half of which bear dorsal spines; disk and ambulacra unplated; radials much wider than the costals, which are rounded and widely separated, not united syzygially; fifty to nearly one hundred arms, all the divisions of two articulated segments; lower brachials discoidal, soon becoming quadrate (wider than long); usually a syzygy between the third and fourth brachial, and others distally at intervals of 6 to 14 bifascial articulations; first brachial pinnule greatly elongated, slender, tapering, and flagellate, with about 40 somewhat elongated segments; following pinnules extremely short, with only 6 to 8 segments, increasing slowly in length distally, but never becoming very long.

Color deep purple or nearly black.

Type of the genus.—*Antedon andersoni* P. H. Carpenter, 1889.

Pontiometra is most closely related to *Himerometra,* but presents several characteristic features of considerable interest; the excessively elongated first pinnule, contrasting sharply with those following, the comparative slenderness and consequent wide separation of the costals, the greatly elongated cirri, with very numerous segments, and the comparatively great length of the brachials, the lower of which, together with the palmars, distichals, and costals, entirely lack the peculiar swollen appearance of those of *Himerometra,* seem to unquestionably warrant generic separation. This genus is as yet only known from the Mergui and Pelew Islands, and from Amboina; the only described species is:

Pontiometra andersoni (P. H. Carpenter)

10. HIMEROMETRA, gen. nov.

Centro-dorsal discoidal, bearing 20 to 40 (usually about 30) cirri in one or two (sometimes three) marginal rows; cirri with 20–40 segments, which are very uniform in size, rarely longer than wide (never much so), medium in length or rather short, moderately stout and smooth, or with small dorsal spines; costals short, united by bifascial articulation, always rounded (never carinate), more or less convex longitudinally, which gives them a characteristic swollen appearance, and usually more or less tubercular at the joint; they may or may not be in apposition, and are sometimes strongly "wall-sided;" distichals and palmars either 2, or 4 (3 + 4) or both; arms ten to about fifty in number, the brachials always much wider than long, with more or less prominent and overlapping distal edges, quadrate or oblong, never triangular; always rounded, and never carinate; disk and ambulacra naked, but the former may have a few small scattered calcareous granules; syzygia irregular, but the third and fourth brachials usually joined by syzygy, and other syzygia at more or less frequent intervals throughout the arms; one or more of the proximal pinnules greatly enlarged, stout, styliform (or more or less recurved), with cylindrical segments, tapering gradually from the base to the slender tip; rarely the distal segments are disproportionately small; distal pinnules slender, the proximal segments not specially marked, the distal not specially elongate.

Color in life purple or reddish purple, the skeleton lighter, often more or less blotched or streaked; sometimes very dark brown or nearly black, but this appears to be a more or less local variation.

Type of the genus.—Antedon crassipinna Hartlaub, 1890.

Himerometra includes parts of Dr. Carpenter's "Milberti," "Palmata," and "Savignii" groups, and a close examination will show it to be a very well defined and homogeneous genus, presenting, as a whole, a number of interesting characters not found in any other. The peculiar swollen appearance of the costals, and usually also of the distichals, palmars, and lower brachials, which are often or usually more or less tubercular, is very characteristic. The costals and lower brachials, with the intervening distichal and palmar series (when present), are always smooth, and never overlap. *Antedon crassipinna* has been chosen as the type first, because it is a distinctly typical species, which *A. milberti* is not, as it never has more than ten arms, and second because it is very common and easily obtainable. *Himerometra* ranges from the Red Sea and east African coast eastward through the East Indies to Japan and the Hawaiian Islands.

The described species referable to the genus *Himerometra* are:

Himerometra abbotti (A. H. Clark)
" *affinis* (Hartlaub)
" *anceps* (P. H. Carpenter)
" *articulata* (J. Müller)
" *bella* (Hartlaub)
" *bengalensis* (Hartlaub)
" *bidens* (Bell)
" *bimaculata* (P. H. Carpenter)
" *brevicuneata* (P. H. Carpenter)
" *brockii* (Hartlaub)
" *clemens* (P. H. Carpenter)
" *crassipinna* (Hartlaub)
" *delicatissima* (A. H. Clark)
" *döderleini* (de Loriol)
" *elongata* (J. Müller)
" *emendatrix* (Bell)
" *erinacea* (Hartlaub)
" *finschii* (Hartlaub
" *flagellata* (J. Müller)
" *gyges* (Bell)
" *helianthus* A. H. Clark
" *imparipinna* (P. H. Carpenter)
" *indica* (Smith)
" *klunzingeri* (Hartlaub)
" *kraepelini* (Hartlaub)
" *lævicirra* (P. H. Carpenter)
" *ludovici* (P. H. Carpenter)
Himerometra marginata (P. H. Carpenter)
" *martensi* (Hartlaub)
" *milberti* (J. Müller)
" *monocantha* (Hartlaub)
" *nematodon* (Hartlaub)
" *occulta* (P. H. Carpenter)
" *okelli* (Chadwick)
" *oxyacantha* (Hartlaub)
" *palmata* (J. Müller)
" *persica* A. H. Clark
" *philiberti* (J. Müller)
" *regalis* (P. H. Carpenter)
" *reginæ* (Bell)
" *quinduplicava* (P. H. Carpenter)
" *reynaudi* (J. Müller)
" *savignii* (J. Müller)
" *spicata* (P. H. Carpenter)
" *spinipinna* (Hartlaub)
" *stylifer* (A. H. Clark)
" *subtilis* (Hartlaub)
" *tenera* (Hartlaub)
" *tenuipinna* (Hartlaub)
" *tessellata* (J. Müller)
" *tuberculata* (P. H. Carpenter)
" *variipinna* (P. H. Carpenter)

11. CYLLOMETRA, gen. nov.

Centro-dorsal discoidal, bearing 15 to 25 marginal cirri more or less regularly arranged in one or two rows; cirri with 15 to 30 segments, very uniform in size and proportions, usually about as long as wide, smooth, or bearing single or paired dorsal spines or a transverse dorsal ridge distally; disk naked or with fine calcareous granules, often segregated in the interambulacral areas; pinnule ambulacra naked; costals rounded, free laterally; ten to thirty arms, the distichals usually (the palmars always) 2, rarely 4 (3 + 4); first few brachials discoidal, then quadrate about as long as wide (or slightly wider than long), becoming elongate distally and more or less "dice-box shaped" at the ends of the arms; distribution of the syzygies irregular; but there is usually one between the third and fourth, second and third, or first and second brachials; one or more of the lower pinnules usually much enlarged, stout, and stiff, the segments with more or less raised and denticulate distal ends; distal pinnules moderate, the first two joints short, the others elongate; normally no pinnule on the fourth (*i. e.*, "third") brachial.

Color in life yellow or white, more or less banded or blotched with purple or red brown; red-brown; rarely red, the pinnules yellow, or entirely red.

Type of the genus.—*Antedon manca* P. H. Carpenter, 1888.

This genus includes seven small but very interesting species, most of which appear to be rather rare or local in their distribution. Dr. Carpenter placed one species near *Antedon milberti* (overlooking the absence of a pinnule on the fourth brachial), two at the end of the "Milberti group," one (under two specific names) in the "Palmata group," and one in the unassigned list at the end of the ten-armed forms. The known species of *Cyllometra* are:

Cyllometra impinnata (P. H. Carpenter)
" *informis* (P. H. Carpenter)
" *belli* (A. H. Clark)[1]
Cyllometra manca (P. H. Carpenter)
" *perspinosa* (P. H. Carpenter)
" *ruber* (A. H. Clark)
Cyllometra tigrina (A. H. Clark)

12. PEROMETRA, gen. nov.

Centro-dorsal conical or hemispherical, usually more or less elongate, the cirrus sockets in usually definite vertical rows; cirri slender, long, composed of 35 to 60 segments, the first few short, then elongate until about the middle of the cirrus (or rather beyond), then squarish; the distal segments bear small dorsal spines; disk and ambulacra naked; rays in close apposition, the costals and lower brachials more or less "wall-sided;" costals united by bifascial articulation; large, often extravagantly elongated tubercles on the junction of the costals, and of the first two brachials; always ten arms, the brachials after the fourth quadrate (sometimes triangular),

[1] *Cyllometra belli*, new name for *Antedon loveni* Bell, 1884, not *Antedon loveni* Bell, 1882.

slightly wider than long in the basal half of the arms, becoming elongate distally; third and fourth brachials usually united by syzygy; a second syzygy between the ninth and tenth, or thirteenth and fourteenth (or at some intermediate point), and others distally with 3 to 8 (usually 4) bifascial articulations intervening; lower pinnules smooth, slender, regularly tapering, flattened exteriorly, the segments longer than wide; distal pinnules long, the first segment very short, the second rather stout and trapezoidal, the others long-cylindrical; the fourth (*i. e.*, "third") brachial always, and the second sometimes, lacks a pinnule.

Color in life reddish purple and white in varying proportions.

Type of the genus.—Antedon diomedeæ A. H. Clark, 1907.

Perometra is only known from the Philippine Islands and southern Japan. The two species belonging to the genus are:

Perometra balanoides (P. H. Carpenter) *Perometra diomedeæ* (A. H. Clark)

13. PTILOMETRA, gen. nov.

Centro-dorsal conical, columnar, or thick-discoidal, the cirri usually in ten definite vertical rows or in five well-separated double rows, occasionally without definite arrangement; cirri very long, rather slender, with 80 to 130 segments, few of which are longer than wide, the distal bearing dorsal spines; disk and ambulacra plated, but sometimes the former nearly naked; costals broad, united by bifascial articulation, in apposition laterally and strongly "wall-sided," not very convex, usually bluntly carinate; ten to thirty arms; distichals and palmars (when present) two, united by bifascial articulation; palmars only developed on outer side of rays; arms rounded at the base, but becoming narrow and compressed distally, where the brachials develop overlapping spines; brachials short-triangular or short-quadrate, the last few terminal joints abruptly turned inward between the distal pinnules, which reach for several millimeters beyond the end of the arms; first pinnule about half (rarely more) as large as the following pinnules; pinnules stout, stiff, strongly prismatic (especially the lower), the first joint short, the rest medium, but little longer than wide.

Color purple, dull yellowish white, or mottled.

Type of the genus.—Alecto macronema J. Müller, 1841.

Ptilometra ranges from Australia northward to southern Japan. I had at first isolated *Alecto macronema,* making it the type of *Ptilometra,* and including the other species in the genus *Asterometra* with *Antedon macropoda* as the type, but further study has led me to combine the two, at least for the present. The known species of *Ptilometra* are:

Ptilometra anthus (A. H. Clark)
" *longicirra* (P. H. Carpenter)
Ptilometra macronema (J. Müller)
" *macropoda* (A. H. Clark)

14. THALASSOMETRA, gen. nov.

Centro-dorsal more or less conical or columnar, the cirri in 10 or 15 vertical rows (rarely without definite arrangement), often in pairs or groups of three, separated from each other by ridges; cirri long and slender, with 25 to 90 segments, the lower longer than wide, the distal short and bearing strong dorsal spines; disk always well plated, ambulacra well plated; costals united by bifascial articulation, deep, strongly "wall-sided;" ten to thirty arms, long, more or less (often much) compressed and carinate, at least distally, the terminal segments not incurved; distichal and palmar series usually 2, rarely 4 (3 + 4); first syzygy usually between the third and fourth brachials (except when the arm springs from an axillary united to the preceding segment by syzygy, in which case it is between the first and second); other syzygies distributed more or less irregularly; first pinnule the largest, long and stout, often greatly enlarged, composed of rather short, but not numerous, segments; other pinnules of moderate length, or rather short, stiff, rather stout, prismatic, the segments moderately elongate, the first two more or less laterally expanded and trapezoidal; terminal pinnules small, becoming gradually very short at the tip of the arm, beyond which they do not extend; the genital pinnules are rarely (?never) specially differentiated.

Color in life bright yellow or yellow and white, sometimes the calyx, rarely the whole animal, dull greenish or brownish.

Type of the genus.—Antedon villosa A. H. Clark, 1907.

This genus includes the larger part of Dr. Carpenter's "Basicurva group," together with part of the "Spinifera group," and one species placed by him in the "Granulifera group" (in addition to being in the "Basicurva group"). Several additional species have been described since the *Challenger* report was written, and I have also examined a few others as yet undescribed. *Thalassometra* has a very wide distribution, occurring pretty generally throughout the tropics, and north to Bering Sea and the coast of Portugal, south to Australia and South Africa. The following described species belong to this genus:

Thalassometra acutiradia (P. H. Carpenter)
" *agassizi* (Hartlaub)
" *alboflava* (A. H. Clark)
" *aster* (A. H. Clark)
" *bispinosa* (P. H. Carpenter)
" *breviradia* (P. H. Carpenter)
" *diadema* (A. H. Clark)
" *duplex* (P. H. Carpenter)
" *echinata* (P. H. Carpenter)
" *hana* (A. H. Clark)
" *hawaiiensis* (A. H. Clark)
" *incerta* (P. H. Carpenter)

Thalassometra latipinna (P. H. Carpenter)
" *lusitanica* (P. H. Carpenter)
" *multispina* (P. H. Carpenter)
" *pergracilis* (A. H. Clark)[1]
" *pubescens* (A. H. Clark)
" *quinquecostata* (P. H. Carpenter)
" *spinicirra* (P. H. Carpenter)
" *spinifera* (P. H. Carpenter)
" *valida* (P. H. Carpenter)
" *villosa* (A. H. Clark)
" *wood-masoni* (Bell)

15. CHARITOMETRA, gen. nov.

Centro-dorsal usually discoidal, rather thick, rarely low-conical or low-hemispherical, the comparatively few cirri usually without definite arrangement; cirri short and stout, with less than 30 segments, very uniform in length, about as long as or slightly longer than wide, not bearing dorsal spines, although the later joints are sometimes tubercular dorsally; an opposing spine always present; disk well, or at least moderately, plated, the ambulacra always well plated; costals and lower brachials strongly flattened against each other laterally, sharply "wall-sided;" distichals and palmars either 2 or 4 (3 + 4), the latter often 2 (1 + 2); ten to about fifty arms, long, always more or less (often much) compressed, at least in the outer half, and carinate; first syzygy between the third and fourth brachial in arms springing direct from the costal axillary, or from an axillary joined to the preceding segment by bifascial articulation, but between the first and second in arms arising from an axillary joined to the preceding segment by syzygy; distal syzygia irregularly distributed; first pinnule (which in *Thalassometra* is much stouter and larger, with larger joints than its successors) rather slender, often more or less flagellate, always less stout than its successors, and composed of more numerous and shorter joints; genital pinnules always have one or more of the joints more or less expanded, protecting the

[1]*Antedon pergracilis;* new name for *Antedon gracilis* P. H. Carpenter, 1888, preoccupied (*cf. Antedon gracilis* de Loriol, 1886).

genital glands; distal pinnules (as well as, to a greater degree, the proximal) stout, prismatic, the segments but little longer than wide; terminal pinnules short, not extending beyond the tip of the arm, which is not incurved.

Color in life yellow or brownish yellow, sometimes more or less marked with white, rarely grayish brown, or gray with the tips of the arms yellow.

Type of the genus.—*Antedon incisa* P. H. Carpenter, 1888.

Charitometra is composed of most of the species included by Dr. Carpenter in the "Basicurva," "Spinifera," and "Granulifera" groups, not falling in the genus *Thalassometra*, with a few others subsequently described, and a number of as yet undescribed forms which I have examined, mostly from the Caribbean Sea. The genus is mainly tropical, but occurs southward to South Africa and the Australian seas, and northward to southern Japan. The following described species are included in the genus:

Charitometra aculeata (P. H. Carpenter)
" *angusticalyx* (P. H. Carpenter)
" *basicurva* (P. H. Carpenter)
" *brevipinna* (Pourtalès)
" *compressa* (P. H. Carpenter)
" *distincta* (P. H. Carpenter)
" *flexilis* (P. H. Carpenter)
" *garrettiana* (A. H. Clark)
" *granulifera* (Pourtalès)
Charitometra hepburniana (A. H. Clark)
" *inæqualis* (P. H. Carpenter)
" *incisa* (P. H. Carpenter)
" *lata* (A. H. Clark)
" *orion* (A. H. Clark)
" *parvipinna* (P. H. Carpenter)
" *patula* (P. H. Carpenter)
" *pourtalesi* (P. H. Carpenter)
" *robusta* (P. H. Carpenter)
" *tuberosa* (P. H. Carpenter)

16. PŒCILOMETRA, gen. nov.

Centro-dorsal hemispherical, subconical, or columnar, bearing 20 to 30 cirri; cirri with 15 to 18 smooth segments, nearly all of which are longer than wide; no opposing spine; terminal claw small and sharp; disk completely plated; ambulacra plated; radials quite concealed in the adult; costals with a thin projecting latero-posterior border, causing them to appear scale-like; costals and lower brachials sharply flattened laterally, the former more or less concave, but not in apposition; ten arms, the brachials as long as or longer than wide, triangular, becoming quadrate distally; first pinnule with 20 to 30 short joints, slender, tapering, and almost flagellate; following pinnules with 3 to 5 of the joints much expanded laterally, enclosing the genital glands, which are covered with strong protecting plates; remaining pinnules prismatic; all the pinnules, especially the lower, have the first joint much wider than its successors.

Color in life, yellow when young, becoming when adult dull yellow-brown or dark gray-brown.

Type of the genus.—*Antedon acœla* P. H. Carpenter, 1888.

Pœcilometra is closely related to *Charitometra,* but it appears to be an invariably ten-armed type. The costals are peculiar in possessing a thin border, continuous laterally and posteriorly, and in having the sides more or less strongly concave, characters which appear to warrant generic differentiation. The range of *Pœcilometra* is from the Meangis Islands north to southern Japan. Two species are known, but the differences between them are not great, and it may be found necessary to unite them at some future time. The later species was wrongly described as belonging to Dr. Carpenter's "Basicurva group," the author having been misled by the association in the same group of *Pœcilometra acœla* and *Calometra discoidea,* two widely different forms. The error is, however, quite inexcusable. The two species of this genus are:

Pœcilometra acœla (P. H. Carpenter) *Pœcilometra scalaris* (A. H. Clark)

17. CALOMETRA, gen. nov.

Centro-dorsal discoidal, bearing 15 to 20 cirri in a single, or partially double or triple, more or less definite marginal row; cirri rather stout, with 20 to 50 segments, the more proximal more or less elongated (but never very much so), the distal very short, usually with small, blunt dorsal spines; disk completely covered with calcareous plates; pinnule and brachial ambulacra well plated; costals rounded, widely free laterally, or furnished with lateral (but not posterior) marginal flanges meeting the flanges on the adjacent rays; distichals (when present) two; palmars two (rarely one), usually articulated, but sometimes united by syzygy; ten to fifty arms of moderate length, rather stout, evenly tapering, the brachials triangular or very obliquely quadrate, almost always longer than wide, convex on the longer edge, becoming shorter distally; position of syzygia irregular; lower pinnules with the first two joints (especially the first) greatly expanded, this character most marked on the first pinnule, which is always small and weak, with small, squarish joints; the second or third pinnules (or both) may be elongated and styliform; pinnules cylindrical, evenly tapering, slender, very stiff and spine-like, the distal with the first two joints short and squarish or trapezoidal, the others greatly elongated.

Color in life very varied; lavendar and yellow; red-brown and yellow; red-brown, purple, yellow, and white; yellow, orange, white, or purple and white, the cirri almost invariably more or less banded with purple and white or yellow.

Type of the genus.—*Antedon callista* A. H. Clark, 1907.

This well marked and handsome genus is found from the Ki Islands northward to southern Japan, where it occurs in great abundance. The only species known to Dr. Carpenter was *Calometra discoidea,* which he placed in his "Acœla group," together with *Pœcilometra acœla.* The next species known was described by Professor Bell under the name of *Antedon bassett-smithi,* in 1894. It was placed by him in the "Spinifera group." The other species have all been recently discovered in the seas about southern Japan. The species of the genus at present known are:

Calometra bassett-smithi (Bell)
" *callista* (A. H. Clark)
" *discoidea* (P. H. Carpenter)
" *flavopurpurea* (A. H. Clark)
Calometra multicolor (A. H. Clark)
" *propinqua* (A. H. Clark)
" *separata* (A. H. Clark)
" *thetis* (A. H. Clark)
Calometra versicolor (A. H. Clark)

18. ADELOMETRA, gen. nov.

Centro-dorsal columnar, bearing ten vertical rows of cirrus-sockets; cirri long and slender, with 60 or 70 segments little, if any, longer than wide, quite uniform in length, the distal third becoming short and developing spines; disk and ambulacra naked; costals comparatively narrow, well separated, the intercostal articulation rising into a tubercle; ten to fifteen (?) arms, distichals 2 or 4 (3 + 4), the brachials all long (all but a very few in the proximal part of the arms longer than wide) and discoidal, squarish, or more or less quadrate; third and fourth brachials united by syzygy, a second syzygy between the thirteenth and fourteenth or sixteenth and seventeenth (or at some intermediate point), and others distally at intervals of from two to seven (usually five or six) bifascial articulations; first pinnule much the longest, with elongated segments; following pinnules much shorter and less stout, becoming longer again and more slender distally.

Color (in spirits): "The skeleton a very light brown, and the perisome darker."

Type of the genus.—*Antedon angustiradia* P. H. Carpenter, 1888.

This genus includes a single species which was placed by Dr. Carpenter in the "Savignii group," but which differs markedly from all the others placed by him in that group. It is:

Adelometra angustiradia (P. H. Carpenter)

Hodgkins Fund

THE AIR-SACS OF THE PIGEON

By BRUNO MÜLLER

The present investigation of the air-sacs of the pigeon was carried out at the Zoölogical Laboratory of the German University at Prague with the assistance of the Hodgkins Fund of the Smithsonian Institution. It was under the supervision of Prof. R. von Lendenfeld, the director of that laboratory. I express my warmest thanks for his active interest in this work, his kindness in placing the necessary facilities at my disposal, and his valuable advice.

Introduction

Although the air-sacs of birds have been carefully investigated by many authors and our knowledge of them is quite extensive, none of the theories advanced concerning their function has found universal acceptance. In this essay an attempt is made to throw more light on this subject. The most reliable basis for a solution of the problem seemed to me to be an exact knowledge of the morphology of the air-sac system in some species of birds known as good fliers and abundantly provided with these organs. Such a bird is the pigeon, and this species appeared particularly suitable because numerous specimens of it are readily obtainable, a consideration of special importance, since, as was soon found, the air-sacs are subject to very considerable variation in different individuals of the same species, which makes it impossible to describe these structures in any species with scientific exactitude without studying them in a large number of specimens. But it was not only this consideration that led me to select the pigeon as the subject of my investigations. I was also led to make this choice by the fact that most of the physiological studies on air-sacs have been carried out with this species. Although much has been written on the morphology of the air-sacs of the pigeon, the data given in the literature on the subject are by no means complete and in several respects inexact; and there exist no correct and comprehensive graphic representations of the air-sac system of this species.

I have not included an historical review of the development of our knowledge of the air-sacs, because such reviews are given in the recent works on this subject by Roché (1891, p. 4), Baer (1896, p. 454), and Bertelli (1900, p. 45). A list of the literature relating to the subject is given at the conclusion of this paper.

METHODS

The investigations were made upon our ordinary semi-domesticated pigeon (*Columba livia*). It is by no means easy to demonstrate the air-sacs with all their diverticula in their true shape and size. Most authors who have studied the morphology of these organs have employed the ordinary injection-method, that is to say, they injected fresh specimens. Although this method, when judiciously applied, may give useful results, it is not free from defects. If the air-sacs are filled with a suitable stiff-setting mass, it is possible, by dissecting out the injected material, to obtain a cast showing the shape of the cavities. Unfortunately it is impossible to expel all the air from the sacs before injecting them, so the injected mass can fill only a portion of the cavities, the spaces occupied by the residual air appearing as hollows in the cast. It is true that the mass penetrates well into the large sacs. These, however, are easily enough demonstrated without injection. Into the smaller diverticula and secondary passages which are hard to find by mere dissection, it penetrates only partially, or not at all. Some authors, as Roché (1891, p. 17) and Plateau (1890, p. 72) have got rid of most of the residual air by means of complicated systems of tubes inserted into the air-sacs; but this method also has its disadvantages. In life the air-sacs are enlarged by pressure on their walls varying locally with the nature of the surrounding structures and the size of the sac; when injected, the walls are subjected to a uniform pressure. The expansion of the various parts of the air-sac system produced by injection is therefore very different from their normal expansion in life.

Results of injections vary also according to the position of the bird during the process; if it is injected when lying on its back the air-sacs are filled in a different manner than if it is injected when lying on its ventral side. It may well be that this unreliability of the injection method is responsible for the mistake made by Baer (1896, vol. XXI, fig. 3*a*) in representing the lung of the pigeon relatively much too small, a mistake which appears to have markedly influenced his views regarding the mechanical work of breathing in birds.

An injection-mass cannot be forced in without using considerable pressure. This causes an abnormal enlargement of the thoracic and abdominal cavities; the crop is pushed forward and the internal organs, especially the intestines, are compressed. The principal expansible parts of the air-sac system appear in such preparations much too large, the secondary diverticula which are less expansible much too small. The high pressure usually bursts the thin walls of the air-sacs in one or two places, causing effusions of the injected material, which may lead to erroneous deductions. I am inclined to suspect that the saccus subpectoralis described by Baer (1896, p. 437) owes its origin, or at least its great size, to a rupture of this sort. This structure is also seen in my injected specimens, but it is an entirely artificial product, arising as an effusion from a sacculation of the diverticulum axillare. Similar effusions are often observed arising from the diverticula that surround the heart.

A better method than the direct injection of a setting mass is the following: A pigeon killed with chloroform or ether is placed in formol, and for a period varying from some days up to two weeks strong formol is also injected with gentle pressure through a canula into the trachea, and thence into the air-sacs. The apparatus I used for this purpose is very simple. I connected a water reservoir with a wash bottle 1.5 m. below it. This produced in the wash bottle a constant and gentle pressure, which was conveyed to a second bottle containing formol, which was thus forced through rubber tubing and a canula into the trachea, and thence into the air-sacs. By this method the air-sacs are hardened in a moderately distended condition. As soon as the hardening is complete, suitable openings can be cut without causing any change in the shape of the air-sacs through collapse, and they can then be satisfactorily injected.

For the injections I used paraffine and gelatine (ten per cent with Berlin blue or carmine). The large air-sacs could easily be completely filled with either material; the smaller diverticula, however, could only be filled with the gelatine and by changing the position of the pigeon many times and using massage during the injection. Even in this way I could not inject all parts of the air-sac system at once, but I succeeded in filling all the parts of the system in different specimens, so that it was possible, by combining the results from a number of pigeons treated in this manner, to obtain a clear conception of their distribution, shape, and size.

The air cavities in the bones can easily be made visible by an injection of glycerine and water with much Berlin blue. The animal was distended with the injected fluid for about 12 hours, during which time it was kept warm, often changed in position, shaken and massaged, and after that it was hardened in alcohol. The pneumatic parts of the bones could then be recognized from without by means of their blue color.

In order to obtain an idea of the degree of expansion of the air-sacs during the various phases of breathing, I strangled several pigeons, some during inspiration and some during expiration, so suddenly that no more air could pass either in or out, and then hardened them by long immersion in formol.

The Air-sac-system in General

In pigeons and other flying birds there are numerous hollow, air-filled spaces, the air-sacs, some of which are very large. Their size varies with the respiratory and other movements. All are connected either directly or indirectly with the bronchi, and through them and the trachea with the outer air. The air passes from the bucco-pharyngeal cavity (fig. 12, CO),[1] into the larynx (fig. 12, L), the trachea (figs. 2, 7, 11, 12, TR), the syrinx (fig. 12, S), and the two bronchi (figs. 9, 10, 12, BR). From the latter two tubes branch off to the air-sacs, of which 10 groups, forming 5 pairs, can be distinguished:

1. Cervical sacs (in the region of the nape of the neck).
2. Interclavicular sacs (adherent to the syrinx and situated ventrally, laterally, and proximally from it).
3. Anterior intermediate sacs.
4. Posterior intermediate sacs.

(in the thoracic cavity).

5. Abdominal sacs (in the abdominal cavity).

Each of the 10 groups consists of a main sac, from which numerous diverticula arise. The latter, as well as the main sacs, possess many secondary diverticula (sacculi).

Before considering the details of the air-sacs it will be well to determine the localities where they are situated and their relations to the diaphragmatic membranes.

The Diaphragmatic Membranes

The open communication between the cavities of the lungs and the air-sacs makes diaphragmatic breathing, as it occurs in mammals, impossible in birds. The diaphragm of birds is quite different in structure and function from that of mammals. It is composed of two parts, viz., the pulmonary diaphragm, which separates the air-sacs from the lungs and effects the expansion of the latter in a man-

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[1] The figures referred to are on plates XLV–XLIX.

ner quite different from that of the mammalian diaphragm; and the abdominal diaphragm, which separates the air-sacs from the intestine and has nothing to do with respiration.

THE PULMONARY DIAPHRAGM (FIG. 1, DIP)

(Anterior, transverse or trilateral diaphragm; Pulmonary aponeurosis, Huxley; Diaphragme pulmonaire, Sappey; Diaphragmite antérieur, Milne Edwards.)

This diaphragm is formed by that portion of the pleura which covers, as an aponeurotic septum, the ventral surface of each lung. The medio-ventral surfaces of the two lungs closely adhere to the diaphragm, which is penetrated by blood-vessels and by the tubes connecting the lungs with the air-sacs. Where the two halves of the pulmonary diaphragm approach each other in the median plane, they adhere to the mediastinum which extends in the shape of a vertical septum in the median plane of the body, is attached to the dorsal vertebræ, and separates the two lungs. This diaphragm, therefore, shuts off from the rest of the body-cavity a special space, the *Cavum pulmonale,* which contains the lungs and the small intra-thoracic portion of the cervical sacs.

Being adherent to the pleura, this membrane assists in the expansion of the lungs during inspiration. It is enabled to perform this function by the two pulmonary muscles of Perrault (fig. 8, MP), which in many birds are strongly developed. In the pigeon these muscles are not so large as in some other birds, as, for example, the cassowary, but they are not at all rudimentary and are certainly functional. These muscles arise from the true ribs near their sterno-costal articulations, and run, parallel to the ribs, obliquely downward to the pulmonary diaphragm. When they contract, this diaphragm is drawn downward and becomes ventrally convex, the pulmonary cavity is enlarged, and the lungs expand. The muscles arising from the anterior ribs are membranous, and unite to form a muscular sheet which, although quite thin in some places, is nowhere pierced by an air-tube. The muscle arising from the lowest rib is more cylindrical in form and not so completely coalesced with those in front as they are with each other. Its insertion coincides with the partition that separates the anterior and posterior sacci intermedii, and extends as far as the proximal edge of the ostium intermedium posterius. From the last rib a second flat pulmonary muscle arises medially, which appears as a branch of the one just mentioned. This muscle extends between the ostium intermedium posterius (figs. 8, 9, 10, 12, OIP) and the ostium posterius (figs. 8, 9, 10, 12, OP), and is attached to the diaphragm.

It crosses the ventral surface of the lung diagonally, whereby it is enabled to assist in the expansion of the pulmonary cavity. The upper muscle of the last rib also follows a somewhat oblique course. All these muscles are innervated by branches of the intercostal nerves.

The Abdominal Diaphragm (Fig. 1, DIA)

(Posterior, oblique, vertical or abdominal diaphragm; Oblique septum, Huxley; Diaphragme thoraco-abdominal, Sappey; Diaphragme postérieur, Milne Edwards.)

This membrane, which is likewise aponeurotic, appears to be a continuation of the ventral border of the mediastinum. It extends from that border on either side, obliquely to the wall of the body cavity, and is attached in front to the pericardium. It therefore incloses a wedge-shaped space (the cavum cardio-abdominale of Huxley), whose base is at the sternum and whose sharp edge is at the ventral border of the mediastinum. It reaches forward as far as the pericardium, and appears there to be shut off by the heart. Backwards, it extends as far as the posterior extremity of the abdominal cavity. In it lie the heart and all the other viscera.

Symmetrically placed on either side of this wedge-shaped space there is a space similar in form whose sharp edge is formed by the union of the pulmonary diaphragm with the outer surface of the abdominal diaphragm. The bases of these secondary cuneiform spaces, the cava subpulmonalia of Huxley, are the lateral walls of the body cavity. Each one of these two spaces is divided by four septa into as many portions, each of which is occupied by an air-sac. The first sac lies, as already mentioned, in the cavum pulmonale. The second extends towards its symmetrical companion of the opposite side and unites with it, where the cavum cardio-abdominale, that elsewhere separates these two cavities, is wanting. The arrangement of the air-sacs is dependent on the development of the diaphragms, which are never pierced by air ducts. When pneumatic connections are present they are in every case extra-thoracic. The general plan of the system is as follows:

In the cavum cardio-abdominale lies the saccus cervicalis;

In the cavum subpulmonale, loculus primus, lies the saccus interclavicularis;

In the cavum subpulmonale, loculus secundus, lies the saccus intermedius anterior;

In the cavum subpulmonale, loculus tertius, lies the saccus intermedius posterior;

In the cavum subpulmonale, loculus quartus, lies the saccus abdominalis.

Before entering on the description of these sacs we will consider more closely the organs from which the air-sacs phylogenetically and ontogenetically arise, the lungs.

The Lungs (Figs. 9, 10; Figs. 1, 2, 11, 12, P)

Each of the two symmetrical lungs has the shape of a three-sided pyramid with posterior base, and a dorsal, a medial, and a ventral face.

The dorsal face of the lung pyramid is convex and of greater extent than the others. It extrudes in the intercostal spaces, the ribs lying in deep, transverse, furrow-like depressions of the lung (fig. 10, C). One of the two edges of the lung-pyramid bounding this face extends along the vertebral column; the other, which is convex downward, extends along the ribs in a line ventral from their uncinate processes. At its lowest point it usually reaches the line of junction between the vertebral and sternal portions of the ribs.

The medial face of the lung pyramid is the smallest in extent. It lies in the median plane of the animal, and is in contact with the mediastinum that separates the two lungs.

The ventral face of the lung pyramid (fig. 9) is more irregular than the two others. Its anterior portion (fig. 9, SICL) is convex, its posterior (fig. 9, SI) concave. Both portions, but especially the anterior one, have a rough appearance, and are in places markedly furrowed. These irregularities are caused by the bronchial branches, many of which lie very near this ventral surface and are covered, on their ventral side, with only a thin membrane. As long as the pleura is intact the ventral surface of the lung appears as if it were really as smooth (fig. 9, PL) as it is generally figured and described in the text-books. If, however, the pleura is removed, the true character of this surface is at once revealed.

Near the center of the ventral face of the lung pyramid the bronchus enters. Within the lung it retains for a considerable distance its cartilaginous character, although rings are not present in its wall. From the place of entrance it extends in an arch, convex towards the ribs, to the ostium posterius (figs. 8, 9, 10, 12, OP), situated near the middle (somewhat nearer the ribs than the median plane) of the posterior border of the lung. The part of the bronchus lying within the lung has been named by Huxley the *mesobronchium*. The anterior portion of this mesobronchium is distended to the *vestibulum* (fig. 10, V), which in many birds has the shape of a large ampulla, but is only slightly developed in the pigeon. In its further course the mesobronchium narrows considerably, and at its posterior end, the ostium posterius, it is not wider than the other air-tubes that approach that opening. In the literature on this subject it is usually stated that the mesobronchium opens into the saccus abdominalis with a wide orifice. Perhaps this may occur normally in other birds; in the pigeon I have seen such an arrangement only once.

From the middle of the mesobronchium there is given off ventrally a branch-canal which, on account of its small caliber, is to be considered an accessory passage. Unlike the mesobronchium, it retains throughout its course the same width. It extends to the ostium intermedium posterius (figs. 8, 9, 10, 12, OIP), which is situated on the posterior border of the lung, laterally and a little ventrally from the ostium posterius. Some distance before reaching this opening the canal lies just below the ventral surface of the lung (fig. 8).

The wall of the mesobronchium is perforated by numerous openings which lead into canals supplying the lung and the air-sacs with air. Those supplying the lung itself are the entobronchia; those extending beyond the lung and supplying the air-sacs, the ectobronchia. Besides numerous small openings, eleven large ones can be distinguished. All these lie upon the dorsal side of the mesobronchium. In the anterior portion of the mesobronchium—that is to say, in the vestibulum—there are four large openings quite close together. From these the entobronchia take their origin. The seven other openings are smaller and situated at nearly equal distances from each other in the remaining central and posterior portions of the mesobronchium. Their size decreases posteriorly. These openings lead into the seven ectobronchia (fig. 10, ECT). Sappey calls the entobronchia "bronches divergentes"; the ectobronchia, because they run near the ribs, "bronches costales." The former are regular, the latter irregular. From the ento- and ectobronchia lateral branches, the parabronchia (Lungenpfeifen; canaux tertiaires, Cuvier; bronchial tubes) are given off. These are so numerous, and the holes in the sides of the ecto- and entobronchia, which lead into them, lie so close together that the walls of these canals have a sieve-like appearance. The angles at which the parabronchia leave the ecto- and entobronchia always closely approach a right angle, but apart from this, these branch canals are variously arranged in one row, in two rows, or spirally. These parabronchia impart to the bird's lung its characteristic appearance. They often anastomose with each other, and I have found that occasionally the parabronchia of different bronchial branches communicate with each other in this manner. With one exception the ento- and ectobronchia do not divide into branches of equal value, but end blindly, gradually thinning out, or terminating in the air-sacs.

The Ostia

Besides the entrance for the bronchus and the already mentioned ostium posterius, each lung possesses four other ostia, the ostium cervicale, claviculare, intermedium anterius, and intermedium posterius. The ostium cervicale (præbronchiale, Gadow; figs. 9, 10, and 12, OC) is penetrated by the distal branch of the ectobronchium primum. It lies between the bronchus and the apex of the lung, and supplies the cervical sac. The ostium claviculare (subbronchiale, Gadow; figs. 9 and 12, OCL) is penetrated by the ectobronchium primum itself. It lies in front of the entrance of the bronchus into the lung, and supplies the interclavicular sac. The ostium intermedium anterius (figs. 9 and 12, OIA) is penetrated by the ectobronchium tertium. It is situated behind and medially from the entrance of the bronchus and supplies the saccus intermedius anterior. The ostium intermedium (figs. 8, 9, 10, and 12, IOP) is penetrated by a special lateral branch of the mesobronchium. It lies near the ostium posterius, and supplies the saccus intermedius posterior.

Concerning the shape of the ostia, it may be remarked that the transition from the lung to the air-sac is somewhat gradual. Eberth (1863, p. 436) has stated that the ciliated epithelium of the air-passages is continued through the ostia posteriora into the abdominal air-sacs. Recent authors have confirmed this, and it is only a question of how far into the air-sacs the ciliated epithelium extends. Eberth (1863, p. 436) reports that he has seen at these ostia oblique and radial muscle fibers. I was unable to verify this, and found no trace of a true muscular sphincter at these ostia.

The Air-sacs

True Air-sacs and Other Air-spaces

I here regard as true air-sacs only those air-filled spaces in the body that arise ontogenetically from branches of the bronchi. The bronchial branches that form the air-sacs develop rapidly, and early invade the body cavity. Besides these true air-sacs, other air-spaces occur. Such are the tracheal labyrinths of ducks and emus (Gadow, 1890), and the pneumatic cavities of the bones of the head.

The Nomenclature of the Parts of the Air-sac-system

In order to avoid confusion I will restrict the term *sac* to the large primary air-spaces, and not use it, as is usually done, also for the processes arising from these primary spaces. These processes I will call *diverticula,* and instead of saying axillary sac, subscapular sac, etc., say axillary diverticulum, subscapular diverticulum, etc. If this terminology be used, the names indicate the morphological value of the part of the air-sac system, for example, that the axillary diverticulum and the interclavicular sac are not structures of the same morphological value and homologous. The *sac* is an enlargement of a bronchial branch; the *diverticulum* an appendage of the sac. Air-spaces that take their origin from diverticula I will call outgrowths or secondary diverticula. According to this nomenclature the pigeon has five pairs of large (primary) air-sacs. Besides these, other true (primary) sacs may exceptionally occur. Gadow (1891, p. 751) mentions numerous openings of the secondary bronchi at the surface of the lung which lead into such sacs. I found such sacs only very rarely, in a few individuals and in varying localities, mostly near the ribs. Having no regularity in their arrangement or occurrence, they are, in the pigeon at least, only to be considered as abnormal structures, and both on that account and because of their small size, can hardly be regarded as possessing any great functional importance.

Relations of the Air-sacs of Birds to Similar Structures in Reptiles

In the chameleon and some other reptiles bronchial branches extending beyond the lungs are observed. These are homologous with the true (primary) air-sacs of birds. At an early stage of development the reptilian lung is similar to that of birds. If, as Milani (1897, p. 47) remarks, we compare a bird's lung with that of *Thalassochelys caretta,* and disregard the adaptive peculiarities of this organ in the latter, we find that the chief air duct of the bird's lung, although shorter, essentially corresponds, so far as it is supported by cartilage, with the intrapulmonary bronchus of the lung of *Thalassochelys,* and that there are structures in the lung of the latter homologous with the bronchial tubes and the parabronchia in the lung of the former.

The Primary Air-sacs

The Sacci cervicales

Synonyms

Bertelli: Sacchi cervicali.
Campana: Réceptacle supérieur postérieur.
Colas: Sac trachélien.
Fatio: Sacci cervales.
Gegenbaur: Sacci cervales.
Gouillot: Réservoirs supralaryngiens.
Huxley: Præbronchial air-sac.
Jacquemin: Poches pneumatiques pectorales.
Merrem: Bulla jugularis.
Milne Edwards: Sacci cervicales (Reservoirs cervicaux).
Owen: Cervical air-cells.
Pagenstecher: Sacci præbronchiales.
Sappey: Sacci cervicales.
Stannius: Vordere thoracale Zelle.
Tiedemann: Cellula cordis posteriora.

The two cervical sacs arise from the right and left ostia cervicalia respectively. According to Selenka (1866, p. 181) they are first visible in the chick on the 11th day of incubation as diminutive protuberances. Bertelli (1900, p. 162) says, regarding their origin in this bird, "Al quinto giorno appariscono gli abbozzi dei sacchi cervicali. Prendono origine dalla meta dorsale della periferia dei tubi pulmonali. Si spingono in avanti prima nelle cavita pleurichi, poi nel tessuta mediastinale e cosi raggiungono il collo." The two (right and left) cervical sacs together form a morphological unit. In the adult pigeon they are paired, quite symmetrical, and not in direct communication with each other. The ostia cervicalia from which they arise lie just behind the bronchus. As, however, these sacs assume the form of dorsoventrally compressed canals, which extend between the pleura and the lung towards the anterior pulmonary wall, the ostia seem, when the pleura is not removed, to lie at the end of the medial third of the anterior margins of the lungs. From these (apparent) ostia the sacci cervicales extend forward, forming two lobes which are closely attached to the ventral and lateral surfaces of the muscles of the neck (figs. 7 and 11, SC; fig. 2, SC). These sacs are small. Their medio-dorsal surfaces touch the ventro-lateral musculature of the neck, their latero-ventral surfaces are parallel to the medio-dorsal ones, and touch the diverticulum œsophageo-tracheale, the diverticula subscapularia of the interclavicular sac (figs. 7 and 11, DOETR), the œsophagus (fig. 7, OE), the trachea (figs. 2, 7, 11, and 12, TR), the vagus nerves and the jugular veins. Ventrally from the vertebral column, the right and left cervical sacs are separated from each other by only a thin partition. Anteriorly they extend to the distal end of the tenth cervical vertebra, posteriorly as far as the lung-margin. The external border clings closely to the musculature of the neck and curves in a dorsal direction, ending with a small oval extension, the pars ovalis (fig. 12, SC 2), which reaches as far as the diverticulum subscapulare. Baer (1896, p. 432) says concerning these sacs: "Von der Lungenspitze entspringend, reichen sie ungefähr bis zur Mitte des letzten Halswirbels." I cannot agree with this. Although I have seen many variations in the length of the cervical sacs, I have never observed them so short as that in the pigeon. In conclusion it should be mentioned that the sacci cervicales communicate with the saccus interclavicularis. This communication is effected by means of the diverticula subscapularia, which are described below.

The Diverticula

While the cervical sacs themselves are simple, their diverticula are complicated. The sacs and their diverticula pneumatize the vertebral column and its muscles. Since the diverticula of the cervical sacs extend both into the neck and into the thorax, they may be divided into two distinct groups or systems belonging to these two regions, the cervical and the thoracic.

The Cervical System

From the proximal end of the pars ovalis (fig. 12, SC 2) of each cervical sac a flattened canal arises which usually penetrates the cervical muscles in the region of the 11th cervical vertebra, and then turns forward, becoming a long, almost straight canal, the canalis intertransversarius (figs. 3, 4, 5, 7, 11, and 12, CI 2). This canal is usually connected with the sac by a second communication further on. Together with the ascending vertebral artery, the vertebral vein and the deep cervical sympathetic nerve, the canalis intertransversarius passes forward through the foramina transversaria formed by the heads and tubercles of the ribs. Beyond a point lying in the region between the 5th and 7th cervical vertebræ this canal (figs. 11 and 12, CI 1) is enlarged like a spindle between the successive foramina transversaria, through which it passes; further on, it becomes simply cylindrical and finally ends on the distal side of the atlas which it pneumatizes (figs. 11 and 12, CI 3).

Two kinds of diverticula are given off from this canal, the diverticula supravertebralia (figs. 3, 4, 5, 7, 11, 12, DSPV) and the diverticula medullaria. The supravertebral diverticula surround the intervertebral articulations and increase the relative mobility of the vertebræ. These diverticula are given off from the anterior ends of the portions (spindle-shaped enlargements) of the canal lying between the successive transverse processes. They extend medially, are club-shaped, and terminate before reaching the median plane. They lie dorsally, behind the vertebræ, and are largest in the middle of the neck, where the relative mobility of the vertebræ is greatest. The medullary diverticula are given off from the cervical canal just in front of the foramina transversaria. They consist of extravertebral and intravertebral portions. The extravertebral portions are small and simple vesicles. The intravertebral portions, which I name diverticula supramedullaria (fig. 12, DSPM 1; figs. 11 and 12, DSPM 2), enter the medullary canal through the intervertebral foramina, and extend dorsally from the spinal cord. Within the medullary canal they widen out and impinge upon the corresponding diverticula of the opposite side. They partly unite with these as well as with the adjacent diverticula (in front and behind) of the same side, to form a continuous canal, sickle-shaped in transverse section, and lying above the medulla, the canalis supramedullaris (figs. 3, 4, 5, 7, and 12, MEA). The partial absorption of the walls of these diverticula which leads to the formation of this canal, takes place during the growth of the bird, and posteriorly, near the thorax, where the canal is widest, is usually quite completed in middle-aged birds. Anteriorly this absorption decreases as the medullary diverticula become smaller, the completely formed supramedullary canal usually extending no farther than the third or fourth cervical vertebra. Anterior to that it is replaced by two rows of isolated diverticula (fig. 12). The posterior end of the supramedullary canal lies near the last cervical vertebra. Occasionally it communicates here with the corresponding canal of the thoracic vertebræ. Very delicate extensions of the canales intertransversarii pneumatize the cervical vertebræ. They penetrate the bone radially, but are otherwise quite irregular.

The Thoracic System

The diverticula of the sacci cervicales in the thorax are arranged like those in the neck, but are not so highly developed. These thoracic diverticula pneumatize the thoracic vertebræ and form a supramedullary canal. Extravertebral outgrowths are absent. From the distal end of the pars ovalis of either side a ventrally flattened tubule arises. This passes between the vertebral muscles and through the intervertebral foramen in front of the first thoracic vertebra into the spinal canal, where it unites with the corresponding tubule from the opposite side, both together forming a duct similar to the canalis supramedullaris (figs. 1, 2, 12, MEP). This duct extends backward but does not reach the last thoracic vertebra. It is very variable, and sends fine branches into the vertebræ and the ribs. According to Baer (1896, p. 434), small diverticula, similar to the canales intertransversarii in the neck, arise from this duct and surround the costo-vertebral articulations. I have not been able to make out anything of this kind in the pigeon. The lungs of the pigeon insinuate themselves so completely between the costo-vertebral articulations that, if such diverticula were present, they would penetrate into the lungs. It has sometimes seemed to me that the ribs were pneumatized directly from the lungs. As a rule, however, the ribs, as is always the case with the vertebræ, are supplied from the medullary canal by means of fine tubules.

The Sacci Cervicales in Other Birds

Almost all birds possess, like the pigeon, sacci cervicales, but in other species they are usually differently shaped. In the stork, the flamingo, and the crested screamer (*Chauna*) they are divided by numerous partitions into a corresponding number of small spaces. In the albatross, Ulrich has found (1904, p. 30) a tripartite division of these sacs into a median unpaired one and two lateral symmetrical ones. In the cockatoo, Bignon discovered (1887, p. 36) lachrymal, ethmoidal, and supramaxillary extensions of the cervical air-sac system. In this bird also occipital, frontal, parietal, quadratal, and mandibular air cavities are found. These, however, are not true (pneumonial) air-sacs, but diverticula of the nasal chambers. A diverticulum of the cervical system which is entirely wanting in the pigeon is described by Baer (1896, p. 434) as follows: "Bei manchen Raubvögeln, beim Bussard, fand ich endlich eine dritte Fortsetzung der Cervikalsäcke. Dieselbe zieht sich als ziemlich weite, in regelmässigen Abständen perlschnurartig eingeschnurte Röhre, nur von Hautmuskeln des Halses bedeckt, zu beiden Seiten der Spinalfortsätze nach oben bis zum Hinterhauptsbein, wo sie blind endigt."

The Saccus Interclavicularis

Synonyms

Bertelli: Sacche interclaviculare.
Campana: Réceptacle superieur antérieur.
Carus: Erster Luftsack.
Colas: Sac cardiaque.
Girardi: Grosse Brustzelle.

Gouillot: Réservoir infralaryngien.
Huxley: Infrabronchial air-sac.
Jacquemin: Poche pneumatique sous-claviculaire.
Merrem: Bulla cordis anterior.
Milne Edwards: Réservoir claviculaire.
Owen: Anterior thoracic cell.
Sappey: Réservoir thoracique.
Tiedemann: Vordere Herzluftzelle.

In full-grown pigeons there is, as in most other birds when full grown, only a single, unpaired, interclavicular sac. This arises from the union in the median plane of two symmetrical, originally completely separate structures. The two distinct sacs which coalesce to form the interclavicular cavity arise from the right and left ostia clavicularia, respectively (figs. 9 and 12, OCL).

In the chick, Bertelli (1900, p. 162) noted these two sacs as early as the sixth day of incubation. They are at first situated dorsally and laterally; they afterwards grow downwards and towards the median plane. They reach their definite position at the end of the eighth day. These sacs give off diverticula which at the time of hatching, have already reached the humerus. Their ingrowth into this bone takes place later. The diverticula of these sacs are very much larger and more complicated than the sacs themselves. As Hunter (1774, p. 209) noted long ago, the median or central portion of the sac is permeated by numerous trabeculæ. Hunter says concerning them: "The superior part of the lungs opens into the large cells of a loose network, through which the trachea, œsophagus, and large vessels, going from, and coming to the head, pass."

The interclavicular sac occupies the anterior part of the thoracic cavity, and extends from the membrane stretched out between the branches of the furculum (fig. 7, MF) to the base of the heart, the sacci intermedii anteriores on both sides of the latter, the free ribs, the coracoid, the ligamentum sterno-furculare, and the anterior portion of the sternum. Dorsally the trachea, the œsophagus, the jugular veins, and the vagus nerves separate it from the cervical sacs. The anterior end of the heart, the great vessels, the bifurcation of the trachea, the two bronchi, and the œsophagus lie pretty freely in the cavity of the interclavicular sac. The various parts of the interclavicular sac occupy the space between these organs. Structures indicating the origin of the sac from two distinct points can not be made out in the full-grown pigeon, but we observe that the whole sac is partially divided into three chambers, a medial and two lateral ones.

The Medial Chamber

The medial chamber contains the trachea and its bifurcation; it reaches posteriorly to the heart, dorsally to the sacci cervicales and the œsophagus and laterally to the two lateral chambers. Along its lateral walls run the common carotid arteries and the jugular veins. It pushes a diverticulum, the diverticulum subcordale (fig. 2, DSC) backward between the heart and the sternum. This diverticulum does not reach the posterior margin of this bone, but it extends a good deal farther than the heart, so that the designation given it by Ulrich (1904, p. 332), diverticulum præcardiale, must be replaced by diverticulum subcordale. There is also a well-developed diverticulum supracordale. This arises behind the former, and is therefore not visible in the section represented in fig. 2. It is rather short, and, unlike the former, somewhat compressed. In the deltoid opening traversed by the arteriæ carotides communes, the medial chamber bulges markedly forward, and thus forms the diverticulum œsophageo-tracheale (figs. 7 and 11, DOETR), which, according to Ulrich (1904, p. 331), extends forward right to the head. This diverticulum is not bilaterally symmetrical. It lies between the œsophagus and the trachea, and partly surrounds the latter—not wholly, part of the trachea being attached to certain muscles of the neck.

The Lateral Chambers

The two lateral chambers are symmetrical with each other. They occupy the remainder of the space whose limits have been described above, and give off the diverticula costalia (figs. 2 and 11, DC) posteriorly (cf. Roché, 1891, p. 64). These diverticula occupy the space between the heart and the sterno-costal bones, and together with the diverticula of the medial chamber, described above, form a pneumatic investment which surrounds the whole of the anterior, larger portion of the heart. Besides these intrathoracic diverticula, extrathoracic diverticula are also given off from the lateral chambers. These are the diverticula subscapularia, suprahumeralia, and sternalia.

The Diverticulum Subscapulare

From each lateral chamber of the interclavicular sac a wide diverticulum, the diverticulum subscapulare (figs. 7, 11, and 12, DSSC 1), arises. This follows the ligamentum sterno-furculare upwards, and, bending backwards farther on, it passes between the upper end of the coracoid and the vertebral column along the brachial plexus. Here only this plexus and a thin membrane separate it from the interclavicular sac itself. Beyond, it extends backwards past the oval diverticulum of the saccus cervicalis, into the space between the scapula and the anterior ribs, where it attains its greatest extent (figs. 2, 11, and 12, DSSC 3). Its posterior end usually lies upon the second true rib under the scapula. Its anterior end reaches as far as the diverticulum œsophageo-tracheale. Near the oval diverticulum of the cervical sac it communicates with the latter by means of a small but sharply defined triangular opening. Sometimes, but not always, I have seen it communicate also with the suprahumeral diverticulum. In these cases a delicate canal passed outward along the lower border of the scapula and the musculus scapulo-humeralis anterior, and opened into the suprahumeral diverticulum near the tuberculum inferius humeri.

It should also be mentioned that in two cases the principal portion of the diverticulum subscapulare was separated from the interclavicular sac and its own proximal portion by a partition which, in the region of the brachial plexus, divided the diverticulum into two chambers. In these cases the subscapular diverticula were, of course, always connected with the suprahumeral diverticulum, and each of the three chambers appeared to give rise to an anterior diverticulum. The communication between the subscapular and suprahumeral is not infrequently present, and by no means restricted to the cases where the principal portion of the subscapular diverticulum is divided from the interclavicular sac. But still, although not uncommon, this is exceptional, and I was much surprised to find this state of things described as the normal condition by Roché, who says (1891, p. 31): "Ces deux derniers (saccules sousscapulaire et humeral) ont une origine commune, sortant du réservoir claviculaire par un orifice ménagé en arrière du muscle petit abducteur de l'humerus." Baer (1896, p. 436) expresses himself similarly. I have not found in the literature on the air-sacs of the pigeon any statement concerning a connection between the diverticulum subscapulare and the saccus cervicalis, but it has been described in the domestic fowl.

From the ventral side of the diverticulum subscapulare an outgrowth (figs. 2, 11, and 12, DSSC 3) arises, which extends, parallel to the second false rib, towards the processus lateralis anterior sterni, without, however, reaching it. It is often broken up into a row of small saccules, and may be so wide at its base that the diverticulum from which it arises appears drawn out locally, as it were, to form it. In this case the outgrowth attains a quite unusual size. The walls of the diverticulum for the most part adhere to the surrounding muscles, only a small portion being free.

The Diverticulum Axillare

From the outer side of each lateral chamber of the interclavicular sac processes arise which extend between the musculus coraco-brachialis posterior and the musculus subcoracoideus, and usually also between the musculus coraco-brachialis brevis and the distal edge of the coracoid. These processes unite to form a spacious chamber, the diverticulum axillare (fig. 11, DA 1). The chamber is more or less completely subdivided into parts, and it has many outgrowths. The connection between its parts is slight, and in many other birds still slighter than in the pigeon. Most authors for this reason distinguish here two such parts, the axillary proper and the subpectoral, as distinct diverticula. The last named is an extension of the axillary diverticulum and lies between the musculus coraco-brachialis brevis and the coracoid. From it a distal outgrowth arises which passes for some distance between the musculus supracoracoideus and the musculus pectoralis major, and is always connected with the diverticulum axillare proper. It does not attain any very considerable size. I do not regard this outgrowth as a true diverticulum; it is not very important, and in two cases was absent altogether.

The principal part of the axillary diverticulum (figs. 2, 11, and 12, DSSC 3) occupies the axillary space between the supracoracoid, subcoracoid, posterior coraco-brachial, great pectoral, and biceps muscles. Medially where it abuts on the subcoracoid and supracoracoid muscles, the axillary vessels and nerves partly pass along its wall and partly penetrate it. The musculus pectoralis major limits the space occupied by this diverticulum on the medial side. Dorsally it extends to the ventral edge of the musculus scapuli humeralis posterior. The part of the membranous wall of the air-sac that divides it from the musculus pectoralis major is free; all the rest is completely adherent to the adjacent muscles. With the exception of a few insignificant fibers in the free membrane, I have found no proper muscular bundles in the wall of this air-sac.

From this diverticulum an outgrowth arises which passes over the short portion of the musculus triceps cubiti (pars humero-cubitalis) and enters the humerus through the foramen pneumaticum of that bone. The pars humero-cubitale of the musculus triceps cubiti arises from the tuberculum minus humeri and the lower part of the crista humeri. Together with the musculus scapuli humeralis posterior it must alternately close and open the foramen during the beating of the wing. I do not think that this has any great physiological significance. More important must be the rhythmic change of volume which the entire diverticulum undergoes during flight. From each outgrowth a communicating canal passes backward to the diverticulum suprahumerale.

The Diverticulum Suprahumerale

This diverticulum (fig. 12, DSH) is much smaller than the axillary one. It covers the head of the humerus, and is bounded by the musculus scapuli humeralis posterior, the musculus triceps cubiti, the musculus biceps brachii, the musculus deltoides major, and the musculus latissimus dorsi. From a small principal cavity, several outgrowths extend between these muscles. It usually communicates, as already mentioned, with the subscapular and axillary diverticula. The connection with the axillary diverticulum is not always developed.

The Diverticulum Sternale

An insignificant diverticulum, hitherto overlooked in the pigeon, arises from the interclavicular sac in the immediate vicinity of the lateral margin of the sternum. This diverticulum (figs. 2 and 11, DST) is attached to the musculus sterno-coracoideus. It is lenticular, and often provided with an outgrowth.

The Variability of the Interclavicular Sac

The interclavicular sac and its diverticula are very variable in the pigeon. Some of these variations have been referred to above. In general it may be said concerning them that the development of this system of air-sacs has a relation to the power of flight of the individual. On comparing these air-sacs in a pigeon that has spent its life in a cage with those found in one that has lived in the open and flown about a good deal, it will be seen that they are much larger and more highly developed in the latter than the former; it appears that disuse of the wings leads to a reduction of these air-sacs.

The Sacci Intermedii

Synonyms

Bertelli: Sacchi intermedii.
Campana: Réceptacles moyens supérieurs et postérieurs.
Colas: Sac hépatique.
Fatio: Sacci infracostales superiores et inferiores.
Gouillot: Réceptacles sous-costaux.
Huxley: Anterior and posterior intermediate air-sacs.
Jacquemin: Poches souscostales, Cellules hépatiques.
Merrem: Erster und zweiter Brustsack.
Owen: Lateral thoracic cells, Cellulæ hepaticæ.
Sappey: Réservoirs diaphragmatiques antérieurs et postérieurs.

The sacci intermedii are two pairs of air-sacs that closely correspond to each other in their configuration. This correspondence is so marked that most authors have given expression to it in the names applied to them. They occupy spaces morphologically and functionally similar between the pulmonary diaphragm, the abdominal diaphragm, and the outer wall of the thorax. These sacs are simple in shape and have no diverticula or secondary communications. The saccus intermedius of each side is divided into two parts, an anterior, the saccus intermedius anterior, and a posterior, the saccus intermedius posterior.

The Sacci Intermedii Anteriores

According to Bertelli (1900, p. 162), these sacs are visible, in the developing chick, on the sixth day of incubation. On the tenth day they appear as flat vesicles spreading over the concave, ventral surfaces of the lungs. They arise from the right and left ostia intermedia anteriora. Once I saw several small ostia in the place of the single one. The sacs themselves (figs. 1, 11, and 12, SIA) occupy the anterior part of the space between the pulmonary and abdominal diaphragms, and are separated from the interclavicular sacs only by the air-sac walls themselves. They are apparently similarly developed in all birds. The following description, given by Roché (1891, p. 32) as that of their general type, applies also to the pigeon: "Les réservoirs antérieurs se trouvent ainsi délimités étant en rapport avec les poumons, en haut; la première côte, et l'artère pulmonaire, de chaque côté, en avant; les côtes en bas; le foie en dehors, ainsi que le cœur et le diverticule précardiaque du sac claviculaire; enfin, les réservoirs postérieurs, en arrière." These sacs are not in direct contact with the lungs, but separated from them by the pulmonary diaphragm. The pulmonary muscles of Perrault protrude into them. Each sac has the shape of a wedge, its base resting on the pulmonary diaphragm and its edge directed ventrally, and lying near the margin of the sternum. Backwards each sac extends to the last rib. Medially its posterior wall bends forward and unites with the pulmonary diaphragm. Since this sac has no free wall—even its medial side adhering to the pulmonary diaphragm—it does not collapse when the body cavity is opened, and it is probable that also during life it does not undergo any considerable changes in volume. It is, of course, strongly dilated during inspiration; since, however, the pulmonary muscles of Perrault undoubtedly draw the lung into the space it occupies this change of volume (dilatation) must to a great extent be compensated.

Irregularities in the structure of these sacs are seldom met with. Once I found near the ostium a few septa that did not, indeed, project far into the sac, but still divided its basal part into several chambers open towards its principal space. The ostium was situated in the largest of these. In another case I found in the left sac a rather stout transverse membrane pierced in the middle by a round hole. This approaches the structure of these sacs in other birds. In *Steatornis* and *Platalea,* for instance, there are two such membranes dividing the cavity of the sac into three parts.

The Sacci Intermedii Posteriores

According to Bertelli these sacs appear in the developing chick on the sixth day of incubation. They (figs. 11 and 12, SIP) arise in the right and left ostium intermedium posterius, and are, in the pigeon as in other birds, asymmetrical, the left sac reaching farther back and being larger than the right. But even the left sac is not so large as either of the sacci intermedii anteriores. The left saccus intermedius posterior extends beyond the last rib into the abdominal cavity; its abdominal portion occupies a narrow slit-like space lying against and partly covering the stomach. When the stomach is pressed against the external abdominal wall this part of the air-sac is undoubtedly compressed and the air driven out of it. The shorter right sac extends but little or not at all beyond the last rib. In a collapsed condition both sacs give the impression that they terminate with an apex attached to the last rib. Owen (1866, p. 212) and Baer (1900, p. 438) describe these sacs as pyramids with bases resting upon the posterior wall of the sac in front and with an apex extending to the pelvic cavity. I have never seen an apex of this sort in good preparations of the air-sacs of the pigeon. The position of these sacs and the way they are attached to the surrounding structures make it appear not improbable that they might assume such a shape when partly evacuated. The sacci intermedii posteriores are in contact with a small portion of the lungs and the wall of the thoraco-abdominal cavity, cover a part of the liver, the abdominal sac, and the intestine, and, on the left side, a part of the stomach. They are not connected with any other sac nor with any pneumatic bones. When the body cavity is opened, they do not completely collapse, because their walls are for the most part attached to the surrounding structures. In most other birds they have the same shape as in the pigeon. Sometimes, as in *Anas* and *Phœnicopterus,* they are considerably larger, reaching in the latter species as far as the anus.

The Sacci Abdominales

Synonyms

Bertelli: Sacchi posteriori.
Campana: Réceptacles inférieurs.
Carus: Quartus magnus saccus æriferus.
Colas: Sac intestinal.
Fatio: Sacci renales et sacci abdominales propriæ dicti.
Gouillot: Réservoírs pneumatiques supérieurs, suprarénales de l'abdomen et abdominales inférieurs.
Huxley: Posterior air-sac.
Jacquemin: Poches pneumatiques sous-fémorales, abdominales et sacrées.
Merrem: Die beiden Bauchsäcke.
Owen: Cellulæ abdominales.
Sappey: Réservoirs abdominaux.

The sacci abdominales are the largest of all the air-sacs. They also appear in the embryo at a much earlier stage than the others. Bertelli says in regard to them (1900, p. 162): "Gli abbozzi dei sacchi posteriori sono i primi ad apparire. Alla settantaduesima ora di prossimità degli estremi caudali un leggerissimo rigonfiamento che è l'abbozzo dei sacchi posteriori, incluso nei legamenti pulmonali-epatici. Gli abbozzi dei sacchi posteriori et i sacchi posteriori sono accolti nei legamenti pulmonali-epatici, nel polmone, nel diaphramma, nelle pareti laterali dell' abdome dalle quali sollevandosi invadoni la cavità abdominale."

The abdominal sacs enter the abdominal cavity dorsally and partly enclose the viscera. Their walls are extremely elastic and almost entirely free. They accordingly cling closely to the organs with which they come in contact, and give off numerous diverticula, which protrude into the spaces between the various viscera and between the latter and the outer wall of the abdomen. The shape and distension of the intestine are constantly changing; reciprocal changes must therefore constantly occur in the shape and distension of these air-sacs. Sexual distinctions and the production of eggs are responsible for reciprocal differences in the size and shape of these sacs in the male and female bird. The variations in the distension of the oviduct are particularly to be considered in this respect. In consequence of all these circumstances the casts of these sacs vary very much in different individuals when injected. In consequence of the asymmetry of the viscera the two abdominal sacs are very asymmetric, the right one (figs. 6, 11, and 12, SAD) being much larger than the left (figs. 11 and 12, SAS), the development of the latter being impeded by the stomach. The difference in relative size of the right and left abdominal sacs is the reverse of that of the sacci intermedii posteriores. In the female, where only the left-hand one of the two oviducts is developed, the difference in size of the abdominal sacs is still greater than in the male.

The abdominal sacs occupy the space limited by the external borders of the posterior parts of the lungs, the sacci intermedii posteriores, the peritoneum, the ilium, the ischium, the pubis, the vena cava, the iliac arteries, the urogenital organs, the organs of the digestive tract, and the roof of the abdominal cavity. In life these sacs are usually only partially distended, more extensive, bladder-like air-spaces being found only at the sides of the cloaca. Everywhere else these sacs and their diverticula are in life narrow or altogether closed folds, containing hardly any air, or no air at all. In injected specimens these parts of the abdominal sacs are often distended beyond their normal size. In the illustrations accompanying this paper these sacs appear larger than they are, the narrow, curved, fold-like diverticula, of which they consist, naturally looking more like thick solid bodies than thin sheets.

The dorsal portion (roof) of the outer abdominal wall is in immediate contact with the abdominal sacs in only one place on each side. On examining the back of a skinned pigeon, one finds that, in the angular space between the pars renalis of the iliac bone and the musculus levator coccygis on either side, a portion of the wall of the abdominal sacs (fig. 6, SAD, SAS) is visible. At these points the sacs are covered by the skin alone, both muscles and bones being absent. In injected specimens the sacs bulge out considerably in these two places, and often form nearly hemispherical protrusions. These are, of course, mere artifacts produced by the abnormal injection-pressure. I might call the attention of physiologists to these portions of their walls, because with some precaution a canula can be introduced here into the system of the air-sacs without injuring the muscles or any other important parts.

The abdominal sacs are very differently arranged in different species of birds, and are, as Baer (1896, p. 40) has demonstrated in the cassowary, entirely absent in *Ratites*.

The Diverticula of the Abdominal Sacs

The abdominal sacs form several diverticula. These lie partly within, partly without the abdominal cavity. Many of the intra-abdominal ones, as, for example, the "duodenal cell" of Owen (1866, p. 212), are, as stated above, variable folds of the principal sac that have insinuated themselves between the viscera. There are, however, besides these, constant processes more like the diverticula of other sacs. Such are the diverticula pelvica, in the vicinity of the lumbar vertebræ, and the diverticula inguinalia, surrounding the head of the femur. The former almost completely surround the kidneys, and extend laterally some distance beyond them. Two pair of processes arising from them enter the ilium and the sacrum, while others extend forward to a considerable distance. Occasionally some of the latter reach, as slender folds, as far as the neighborhood of the posterior border of the lungs. I have often seen a fold of this kind over the proventriculus. In fig. 11 this diverticulum is represented as not extending so far forward.

The inguinal diverticula appear to be quite constant in the pigeon. I will give a more detailed account of them because they have not been described by previous authors.

The Diverticula Inguinalia

The inguinal diverticula surround the head of the femur and send slender processes in between the muscles of the thigh. From each of the two abdominal sacs a rather wide canal arises which passes out from the abdominal cavity at the acute, backwardly directed angle between the lateral edge of the præacetabular portion of the ilium (pars glutæa) and the musculus ilio-femoralis internus. This canal extends outside the abdominal cavity forming a little sac, the diverticulum femorale anterius (figs. 11 and 12, DFA), which overlies the musculus femori-tibialis. This diverticulum is usually connected with the abdominal sac not only by this canal, but also by another narrower tubule, the canalis præacetabularis (figs. 11 and 12, CPRA), which lies in front of the other, and runs along the lateral margin of the pars glutæa ilii. In one case this canal, which passes over the musculus ilio-femoralis internus, gave off an accessory dendritically ramified branch. This may have been a malformation. The diverticulum itself consists of several chambers freely communicating with each other, and occupies the space between the ilium, the musculus ilio-femoralis internus, the three united musculi ilio-trochanterici anterior, posterior and medius, the flat, tendon-like end of the musculus ilio-femoralis externus, and the head of the femur. One of these chambers, the diverticulum femorale superius (figs. 6, 11, and 12, DFS), is flattened, and extends between the musculi pubo-ischio-femoralis, femoro-tibialis, ambiens, and ilio-tibialis internus. Another diverticulum arising from the abdominal sac, the diverticulum femorale posterius (figs. 11 and 12, DFP), passes out through the foramen ischiadicum. This forms three small chambers covered for the greater part by the musculus ilio-fibularis. This diverticulum femorale posterius and the diverticulum femorale anterius, described above, form the inguinal diverticulum of Owen. I have never observed the diverticulum that Baer describes (1896, p. 440) as passing out through the foramen obturatorium. As Baer also mentions nerves and vessels coming out through this foramen, it appears probable that there is here some confusion of nomenclature. Considering the lack of precision in much of the anatomical data concerning birds, such a confusion is likely enough to arise.

The inguinal diverticula surround the acetabulum on all sides, so that the head of the femur rests upon a ring of air-cushions. This arrangement doubtless increases the mobility of the femur and reduces the friction of the adjacent muscles.

The uppermost chamber of the inguinal system, the diverticulum femorale superius (figs. 6, 11 and 12, DFS), is covered only by the flat tendon of the musculus ilio-femoralis externus and the skin, so that its situation is similar to that of the superficial portion of the abdominal sac above mentioned (fig. 6, SAD, SAS). A penetration of this diverticulum, which is a branch of the præfemoral diverticulum, does not, however, give as satisfactory physiological results as a penetration of the wall of the abdominal sac, because the præfemoral diverticulum communicates with the other parts of the air-sac system only by very devious and narrow passages which are easily closed by the contraction of the contiguous muscles.

General Considerations Concerning the Air-sacs of the Pigeon that Lie Between the Soft Parts.

While the air-sacs of the pigeon show a great diversity in detail and are in some regions subject to very considerable variations, they are, in their general features, constant enough to enable one to give an account of their typical form. I have not regarded in the foregoing descriptions the numerous pathological divergences from the normal type met with in the investigation. The pathological changes and other variations in size that affect the liver and other organs have a marked influence upon the air-sacs. The deposits of fat found so frequently about the pericardium and elsewhere, in spaces that would otherwise be occupied by air-sacs, also play an important part in this respect.

Subcutaneous air-spaces, such as occur in the pelican and some other birds, are entirely absent in the pigeon. I have, it is true, often found the injected gelatine or paraffine under the skin of pigeons, but I found that in every such case the wall of an air-sac had been ruptured, and the mass had then effused. It may be possible that such injuries of the air-sac wall sometimes occur in the living animal without fatal result by the rupture of an extra-thoracic diverticulum. I twice found pneumatized bones which had been broken, and had healed.

The Pneumaticity of the Bones

The air-sacs, their diverticula and outgrowths, send processes into many bones. These expand there by pushing aside the marrow, the bones thus becoming pneumatized. The sacci cervicales pneumatize the cervical and dorsal vertebræ and the ribs. The latter are sometimes also pneumatized directly from the bronchial branches of the lungs. The intrathoracic diverticula of the saccus interclavicularis pneumatize the sternum and the sterno-costal bones; its subscapular diverticula pneumatize the coracoids, the furculum, and the scapulæ, and its axillary diverticula pneumatize the humeri. The sacci intermedii anteriores and posteriores do not pneumatize any bones. The sacci abdominales pneumatize the bones of the pelvis and the lumbar and the sacral vertebræ.

All the bones of the neck and trunk, as well as the humeri, are pneumatized. All bones situated distally from the humerus in the anterior extremity and all the bones of the posterior extremity are filled with marrow and not pneumatized. The bones of the skull are partly pneumatized, not by the pulmonary air-sacs, but from the nasal air-spaces. All air-sacs that possess diverticula also pneumatize bones. The sacci intermedii anteriores and posteriores have no diverticula, and they alone pneumatize no bones.

The pneumatic bones are strikingly different from the medullated ones. Since they are free from marrow and fat, they are lighter in color and usually so transparent that their internal structure, the lamellæ and trabeculæ, can be seen through their walls. The walls of such bones are thinner, more compact, and more brittle than those of medullated bones, a part of the spongiosa and the innermost layer of the compact substance of the wall appearing to have been re-absorbed. The delicate membranous wall of the air-sac is applied immediately to the nearly smooth inner surfaces of the bone.

The Pneumatic Foramina of the Bones

In each pneumatic bone there is found a pneumatic foramen through which an air-sac sends a process into the bone. The situation of the foramen is constant for each bone; its size and form are, however, variable. Strasser (1877, p. 192) was the first to consider the causes of that constancy and this variability. In mechanically unimportant places the osteoclasts destroy the bony substance and the osteoblasts do not produce any. Thus foramina are formed through which the outgrowths of the air-sacs enter. The pneumatic foramen is accordingly always found where the pressure, traction, and torsion are least, a place determined under normal conditions by the mechanical forces acting on each bone. The boundary of this area of least stress, where the foramen is formed, is naturally not sharply defined, and subsequently its margins are often partly covered with osseous substance. These factors determine the constancy of the location of these foramina and the variability of their shape and size. The foramen is either simply circular or oval in form, sometimes, however, through subsequent deposit of bone, divided into several smaller apertures and sieve-like. In the sternum there is always a large foramen at the bottom of the concavity of its upper side. Usually there are also other foramina on its upper surface on either side, less frequently on one side only, which form a row parallel to its lateral margin. The size of these foramina is very variable. Sometimes a third, median, row of foramina is found on the upper surface of the sternum. This shows that the occurrence of these rows of foramina is very variable, whilst the position where they occur when they are formed is always the same. These parts of the bony wall, being unimportant mechanically, are very thin when no foramina are present.

The principal pneumatic foramen of the scapula lies near its articular end; that of the coracoid on the inner surface of the canalis triosseus; that of the clavicle at the broad, spoon-shaped, scapular end; that of the humerus at the bottom of the deep depression on the anterior side of its basal portion; those of the ribs lie on their concave surfaces near the joints; those of the sterno-costalia on their concave surfaces near the sternal border; those of the pelvic bones on their ventral surface, usually above the kidneys; those of the cervical vertebræ on the surfaces turned towards the canalis intertransversarius and at other places, for example, on the distal end of the atlas; and those of the dorsal vertebræ in various places.

The Pneumaticity of Bones in Different Birds

The foramen is formed, and the air-sac enters it at a comparatively late period, when the development of the bone is already quite complete, so that the bones of very young birds are not pneumatic. In the adult stage *Archæopteryx* and *Hesperornis* (Marsh) had no pneumatic bones at all, and *Apteryx,* the *Odontornithes,* and the New Zealand moa have only a few. The development of pneumaticity in bones appears in birds to have gone hand in hand with their phylogenetic development. Among recent birds the pneumaticity of bones is in general directly correlated with the power of flight and the size of the body. It is most highly developed in large birds of great flying power, such as the vultures, pelicans, swans, and albatrosses. Small birds, even when good fliers like the swift, usually have medullated bones. As there are obviously unknown factors influencing the pneumaticity, besides the known factors of size and flight-power, it is difficult to say beforehand to what degree the bones of any bird may be pneumatic. It is noteworthy that some large reptilian Sauropsida, such as the gigantic *Atlantosaurus, Brontosaurus,* etc., had pneumatized bones with air-cavities, while the bones of small reptiles are not pneumatic. This shows how important the size of the body is in this respect.

The Minute Structure of the Air-sacs

The thin membranes forming the walls of the air-sacs consist chiefly of connective tissue composed of long, coarse, slightly wavy fibrillæ, to which are added, in all the sac-walls with the exception of those in the pneumatic bones, spirally twisted elastic fibers (cf. *Leydig,* 1857, p. 376). The latter render the walls of the sacs in the soft parts of the body elastic, and almost equally extensible in every direction. In this connective-tissue membrane, the membrana propria, the blood-vessels of the sac-wall are situated. In the walls of the sacs that lie between the soft parts only few blood-vessels are found (Strasser, 1877, p. 205; Baer, 1896, p. 451). In the walls of the sacs situated in the bones there are, on the contrary, numerous blood-vessels and a rich capillary network. The respiratory interchange of gases is therefore much more marked in the walls of the sacs in bones than in those situated between the soft parts. All blood-vessels of the air-sac walls belong to the general circulatory system of the body, none to the pulmonary system. Of nerves only a few are observed in the air-sac walls.

Internally the sac-wall is lined with a single layer of epithelial cells. In the vicinity of the ostia this epithelium is high and ciliated; farther on it gradually changes to a low pavement epithelium without cilia. This arrangement of the epithelia in the air-sacs is well shown by the appearances observed in older city pigeons, where all parts of the walls of the sacs, except those near the ostia, where the inhaled dust is ejected by the cilia, are strongly impregnated with soot. The condition of the atmosphere of Prague, in which lived the pigeons examined, is very favorable to the development of this phenomenon! By treatment with nitrate of silver the boundaries of the irregularly polygonal cells, of which the pavement epithelium of the distal portions of the air-sacs is composed, are easily demonstrated. According to Fourneux and Hermann (1876, p. 218), these cells are similar to those of the epithelium of the posterior portion of the lungs of snakes. A similar epithelium, composed, however, of somewhat larger cells, clothes the walls of the sacs within the cavities of the pneumatic bones. In some places there are found, between these cells, groups of smaller ones, the true nature of which is doubtful. Baer (1896, p. 450) regards them as growth-centers for the pavement epithelium, and believes that the larger cells are produced by a coalescence of such smaller ones.

Externally the membrana propria of the air-sac wall is covered, wherever it is free, by an endothelium whose cells are somewhat smaller than those of the inner epithelium. In this external endothelial layer lymph-stomata occur.

Contrary to the accounts given by Lereboullet (1838), Leydig (1857, p. 376), and Eberth (1863, p. 434), I have never been able to find muscles in the proper walls of the air-sacs of pigeons; at the places where these authors thought they saw them I failed to see anything but bundles or strands of elastic fibers. Such occur in the wall of the interclavicular sac near the furcula, in the wall of the cervical sacs (cf. Sappey, 1874, p. 38), and elsewhere. In this respect my results agree with Baer's (1896, p. 448).

A good résumé of the literature relating to the structure of the walls of the air-sacs is found in Oppel (1905, p. 333).

The Function of the Air-sacs

Much has been written on the function of the air-sacs and the advantages birds derive from their possession; that, however, which I hold to be their true nature and utility has either been overlooked altogether or far underrated in importance.

The most important hypotheses advanced concerning the function of the air-sacs are the following:

One hypothesis is that the air-sacs serve to erect the feathers. Since, however, this could only be effected by subcutaneous sacs, such as occur in the pelican, and since such sacs are wanting in most birds, including the pigeon, this hypothesis certainly cannot be considered as satisfactory.

Many authors advocate the view that the air-sacs are resonatory organs for the purpose of increasing the strength of the voice. The similarity in the structure of the air-sacs in the sound-producing males and in the silent females shows the untenability of this view.

The hypothesis advanced by Cuvier (1810), Meckel (1821), Jacquemin (1842), Milne Edwards (1857), Owen (1866), and Magnus (1869), that the air-sacs are directly respiratory in function, has been refuted first by Sappey (1847, p. 48), and since by so many others, that we only need to refer to what we have mentioned above, viz., the slight development of the capillary system in the walls of the air-sacs, in order to demonstrate the incorrectness of this idea.

The statement made by Sappey (1846), Lendenfeld (1897), and other authors that the specific gravity of birds is reduced by the air-sacs contained in their bodies although opposed by Ficalbi (1884), P. Schulz (1896), Madarasz (1899), and to some degree likewise by Baer (1897), is of course incontrovertible. It is, however, questionable whether such a reduction of specific gravity, accompanied as it is by an increase of volume, can be of any use to the bird. It seems to me that this could not be of any advantage to sailing birds like the albatross, and that it would be directly disadvantageous to birds like the pigeon that move their wings rapidly. A reduction of the specific gravity obtained by inflating the body could only, it seems to me, be of use to those ancestors of birds that were accustomed to employ their wings as parachutes for effecting long jumps.

Campanas (1875), Pagenstecher (1878), Bignous (1889), and Soums (1896) consider the evaporation of water on their walls as the most important function of the air-sacs, and Madarász (1899) has suggested that the moist walls of the air-sacs may functionally replace the sweat-glands of mammals. Also Vescovi (1894) holds this opinion and considers the air-sacs as organs assisting in the regulation of the body temperature. I, for my part, do not believe that the air-sacs are a temperature-regulating apparatus, and agree with Baer (1894) in the doubts he expresses concerning this hypothesis. Considering the high body-temperature of birds, an extensive cooling apparatus is surely unnecessary.

Madarász (1899) thinks that the air-sacs of birds are analogous to the swimming bladders of fishes, and, like them, manometric sense-organs comparable to aneroids. That the air-sacs should be there to inform a bird of his height above sea-level seems to me, in view of their irregularity and great extent, highly improbable.

Hunter (1774) and Owen (1886, p. 217) have advanced the view that the air-sacs (when inflated) serve to fix the wings in the extended position. The latter says (l. c.) concerning this: "A fourth use of the air-receptacles relates to the mechanical assistance which they afford to the muscles of the wings. This was suggested by observing that an inflation of the air-cells in a gigantic crane (*Ciconia argala*) was followed by an extension of the wings, as the air found its way along the brachial and antibrachial cells. In large birds, therefore, which, like the Argala, hover with a sailing motion for a long-continued period in the upper regions of the air, the muscular exertion of keeping the wings outstretched will be lessened by the tendency of the distended air-cells to maintain that condition." To this I must remark that a soaring bird holds its wings horizontally without muscular effort, and hangs from them, so that a special apparatus for their fixation in this position is unnecessary.

Most recent authors consider the air-sac system as an apparatus serving as a mechanical adjunct to the respiratory system. This theory that they are bellows appears at first sight to have much in its favor. Even Harvey (1651), who was the first to carefully describe the air-sacs, entertained this opinion. This hypothesis was further developed by Perrault (1666), who pointed out that the respiratory changes in the volume of the thorax must cause a change of the air in the air-sacs. He thought these movements were of such a nature as to cause an antagonism between the sacci intermedii and the sacci abdominales. According to him the air passes from the sacci abdominales into the sacci intermedii during inspiration; and conversely, from the sacci intermedii to the sacci abdominales during expiration. Girardi (1784), and especially Sappey (1847) and Siefert (1896), have warmly supported this theory. Campana (1875) was also of this opinion, but he thought that extra-thoracic sacs (portions of sacs) were compressed by the circumjacent muscles. In 1816 Fuld disputed Perrault's theory of the alternate inflation of the air-sacs, and his views were supported by Roché (1891), Soum (1896), and others. Baer (1896, p. 477) concludes, from anatomical considerations and physiological experiments, that there is no antagonism of the kind suggested by Perrault in the movements (expansions) of the various groups of air-sacs, and he thinks it far more probable that all air-sacs are enlarged during inspiration, and, conversely, all contracted during expiration. I cannot wholly agree to this, as I do not believe that the cervical sacs and extra-thoracic diverticula of other sacs enlarge and contract during respiration at all. Baer, indeed, paid no attention to the extra-thoracic air-spaces. This certainly was not justifiable, for, taking them altogether, especially if we include among them the non-dilatable air-spaces in the pneumatic bones, their volume is by no means insignificant. That the ventral wall of the body appears somewhat drawn inward during inspiration does not prove that there is a decrease of volume during this respiratory phase, but it shows, at least, that there can be no noticeable enlargement of the abdominal sacs during inspiration. In the sacci intermedii the increase of volume during inspiration is also in realty not so great as at first sight appears.

There is, of course, an increase in the size of the thoracic space during inspiration. This is effected by a movement of the sternum downward and forward, whereby the angles between the vertebral and sternal pieces of the ribs are increased. Thus the thoracic space gains in height. The increase of transverse dimensions that occurs at the same time is insignificant. Dorsally the lungs adhere to the ribs, and even extend between them. To the concave ventral surface of the lungs are attached the muscle of Perrault which contract during inspiration. By the enlargement of the thoracic cavity the atmospheric pressure in the thoracic air-sacs is reduced. These air-sacs are chiefly situated ventrally from the lungs. The difference between the (lower) pressure in these sacs and the (higher) pressure outside will indeed be diminished in amount during inspiration by the influx of air through the ostia into the sacs; yet on account of the smallness of the ostia some time must always elapse before the pressure within and without is completely equalized. Until this equalization is complete the air-sacs below the lungs, in which the pressure is low, and the muscles of Perrault must draw the ventral surface of the lungs downwards, thus effecting an expansion of the lungs. Baer himself has (1896, p. 476) pointed out that, in the first period of inspiration, there is a relatively very low air-pressure in the sacci intermedii. The consequence of this is that at that respiratory phase the ventral wall of the abdomen sinks in, notwithstanding the fact that it is very thick and muscular, and that it tends to become tense during inspiration and opposes a marked resistance to the depression. The thin wall of the pulmonary diaphragm certainly cannot withstand such a difference of pressure better than this external body wall; it must be pulled downward, and when the pulmonary diaphragm is thus depressed the lungs must necessarily expand. That no complete equalization occurs between the external and internal air pressure during inspiration is stated by Baer (1896, p. 478) in the following words: "Bevor noch der Spannungsunterschied zwischen der äusseren Atmosphaere und der Luft der Säcke sich gänzlich ausgeglichen hat, beginnt die expiratorische Verengung des Brustkorbes. . . ."

At the time of the expiratory contraction of the thorax there arises, conversely, an excess of pressure in the intra-thoracic air-sacs. They press against the lungs and compress them wherever they are in contact with them. If the thorax of a living animal is opened the assistance given by the varying pressure of the sacci intermedii ceases and the changes of volume, which are then induced by the muscles of Perrault only, are less than under normal conditions. This circumstance may well be the principal reason for the undue underrating of the respiratory lung movements by a great number of recent authors.

I will by no means deny that there occurs during respiration an exchange of air between the air-sacs and the outer atmosphere. But I fail to see how this can appreciably assist the pulmonary respiration. The expansion and contraction of the lungs is synchronous with that of the air-sacs. During inspiration all parts of these organs draw air out of the bronchi. During expiration the air-sacs do indeed eject some air into the bronchial branches, but this cannot reach the parabronchia, because the latter, during respiration, likewise contract and eject air. If the air thus ejected from the air-sacs does not pass through the parabronchia, it cannot enter the alveoli which branch off from them, and in which the blood oxidation takes place (cf. Siefert, 1896, p. 476; and Lendenfeld, 1896, p. 776). The structure of the lungs, which has been described above, precludes the possibility of this air passing through the parabronchia by following the few narrow communications that exist here and there. But even if it were so, such an arrangement could hardly aid in the respiratory function. Let us suppose that during inspiration the lungs and air-sacs are filled with fresh air. The air which reaches the lungs would there give off a portion of its oxygen; that in the air-sacs would not. During expiration the air from the lungs would be driven out through the bronchi into the trachea, and the air from the sacs would pass into the lungs. There the latter air would be deprived of a portion of its oxygen. During the next inspiration this air (poor in oxygen) would again pass from the lungs into the air-sacs. During the next expiration the same air would then again fill the lungs, and these would thus always contain air poor in oxygen, and therefore ill adapted for respiratory purposes.

There is also a second important circumstance in relation to this subject that appears to have hitherto been overlooked. In birds we find the trachea relatively much larger and the lungs relatively much smaller, richer in capillaries, and heavier than in mammals. Consequently the volume of air contained in the lungs of birds is relatively much smaller than the volume of air contained in the lungs of mammals. Even during the most powerful expiration only a part of this small allowance of air is renewed by respiration, a considerable portion remaining in the lungs as "residual" air. The amount of air that is really expelled from the lungs would hardly suffice to fill the very spacious trachea, on which account a large portion of the air during respiration would only flow backward and forward between the lungs and trachea, if this were not prevented by special arrangements. Without such special arrangements oxygen would be supplied to the respired air only by the slight mixing of tracheal with external air at the nostrils, and a proper oxidation of the blood would be impossible.

In consequence of the change in volume of the air-sacs during respiration the body of air moved is much greater, and thus the above-mentioned disadvantage to breathing, that would otherwise result from the great extent of the trachea is averted. The air that leaves the air-sacs during expiration passes the ectobronchial branches, and, together with the air that comes from the alveoli of the lungs, enters the trachea, and is in great part expelled through the nostrils. An equally large volume is thereupon again inhaled. This is then, together with the air remaining in the trachea, distributed among the air-sacs and the lungs. In this way, indirectly, and in no other way, the air-sacs assist in respiration.

The width of the trachea diminishes the air-friction, and thus economizes the labor of breathing, which, in view of the considerable length of that organ, is of considerable importance. The length of the trachea is determined by the length of the neck, and the latter affords advantages of quite another sort. The length of the neck in the flying Sauropsida, selectively acquired for other purposes, was one of the causes of the development of the air-sac system, through which its disadvantages in respect to respiration were compensated.

The extra-thoracic air-sacs occupy interstices between the muscles and other parts of the locomotory apparatus. According to Strasser, this is an advantage, because in consequence there is "geringere Kraft an innerer Arbeit verloren" (1877, p. 205); and (Strasser, 1877, p. 206) there is a "Gewinn an Grösse des Bewegungshebels und an Bewegungsleistung ohne entsprechende Vermehrung der Muskulatur und der übrigen Organsysteme;" as well as (Strasser, 1877, p. 207) "eine Vermehrung der Leistung, durch eine Verschielung der Muskeleinheiten nach der Seite der günstigeren Wirkung hin." I not only share these views of Strasser concerning the extra-thoracic air-sacs, but believe that the intra-thoracic air-sacs also serve such a mechanical purpose. The mechanical advantages which the intra-thoracic air-sacs render are: 1st, an increase in the size of the thorax without an increase in weight; and, 2d, an increase in the freedom of movement of the organs contained in it, especially of the heart.

The advantage of an increase in size of the thorax without increase of weight is clear enough. The strength of hollow cylinders differing from each other in diameter only is proportional to their transverse diameter. The same is the case with other similarly shaped bodies not exactly cylindrical in shape. By the coalescence of the dorsal vertebræ, the paratangential extension and coalescence of the bones of the pelvis, the clenching of the ribs by means of the uncinate processes, the development of the sterno-costal bones, and finally by the special structure of the sternum and coracoid, the support of the wall of the thorax of the bird has attained the shape of such a hollow cylinder. The above-mentioned mechanical law therefore also applies to it. The same laws of structure which, as Schwendener found everywhere governing the structure of the elastic portions of plants, and which likewise invariably regulate the structure of the bones in animals, control the configuration of the avian thorax, where they find an expression in the development of the intra-thoracic air-spaces. The same law also affects the organization of flying insects, especially those which are good fliers, for such insects also possess air-sacs. It even applies to the flying fish, which have very much larger swimming bladders than other fishes. That this extension of the thorax, without increase of weight, by means of the interpolation of air-spaces, which occurs in such widely separated animal groups, essentially increases the mechanical aptitude for flight cannot be doubted by any one acquainted with the laws of mechanics.

There is yet another circumstance greatly in favor of the view that the function and raison d'être of the air-sacs are mechanical and not respiratory. This circumstance is their asymmetry, which, strangely enough, has not been noticed in this connection by any previous author. Baer, whom we must regard as the principal exponent of the respiratory bellows-theory of the air-sacs, has worked out a scheme, based on exhaustive studies and experiments, on the enlargement of the body-cavity of birds during respiration, which gives a clear and accurate account of the respiratory mechanism. This scheme shows that the enlargement is greatest at the posterior end of the thorax, and decreases anteriorly. The abdominal sacs must, therefore, take in the most air, the sacci intermedii posteriores less, the sacci intermedii anteriores still less, and the saccus interclavicularis least of all. As the external wall of the thorax, the respiratory muscles, and the lungs are all symmetrical, we would, if the air-sacs were merely accessory bellows for the lungs, also expect that each pair of sacs would be symmetrical. And this symmetry should be most clearly pronounced in the largest of all the sacs—that is, the abdominal ones—because, as above mentioned, these sacs are the ones which change their volume most during respiration. In fact, however, this pair of sacs is altogether asymmetrical and dissimilar in size. It is true that the sacci intermedii posteriores are, like the sacci abdominales, asymmetrical, and dissimilar in size in a reverse sense, but their capacity is so small when compared with that of the abdominal sacs that they do not by any means compensate the disturbance occasioned by the asymmetry of the latter. The power necessary to work a small air-sac efficiently as a bellows is very different from that required to work a large one. The asymmetry of the abdominal sacs would, therefore, if they really were, as Baer believes, bellows, make it necessary that the muscles compressing them should also be asymmetrical, which is not the case. The sacci intermedii anteriores and posteriores often consist of two parts, one of which is frequently connected with the other by means of a small opening, but often not directly connected with the lung at all. The complete separation of this air-space from the lung can only have been produced by a secondary closing of the original opening. Such a secondary closing would certainly not have occurred if this space were a bellows employed for breathing. Sometimes, through this bipartite division, the air-sac proper is greatly reduced in dimensions, often by half its size: another asymmetry. Besides, it may be remarked, that the two ostia forming a pair, especially those of the interclavicular sac, are often asymmetrically placed.

All this appears in a very different light if we consider the thoracic air-sacs as structures selectively developed for the purpose of increasing the size of the thorax without increasing its weight and facilitating the movements of the organs in the thorax, chiefly the heart. Then it becomes evident that the shape of the air-sacs is of no importance, and that their asymmetry is simply caused by the asymmetry of the spaces they have to occupy between the asymmetrical viscera.

The increase of mobility of the internal organs, especially the heart, due to the air-sacs, is of especial importance on account of the rigidity of the wall of the thorax. Since in birds the pericardium and the amount of pericardial fluid contained in it are small, the heart, if there were no air-sacs around it, could hardly move at all. In birds the heart is relatively much larger, and beats with greater energy and rapidity than in mammals. This energetic heart-movement is necessary for the production of the power required for flight, and it is made possible by the diverticula of the saccus interclavicularis which surround it. The movements of the gizzard, the peristaltic action of the intestine and the oviduct are also made easier by the portions of air-sacs that surround these parts. The pneumaticity reduces the friction to a minimum, whereby a considerable economy of labor is effected.

Merrem and Perrault suggested that the alternation of positive and negative pressure in the air-sacs may help to mix the contents of the intestines, and so assist digestion. I cannot share this view.

Sappey (1846) considered the air-sac system as an apparatus for equilibration. I do not think, however, that they can act as such, for Lendenfeld has shown (1897) that the shifting of the center of gravity occasioned by the alternate filling and emptying of the sacs cannot be great. A balancing of the body during flight by the filling of single air-sacs seems to me neither useful nor possible. Slight alterations in the position of the head or the extremities are in this respect much more effective than a shifting of the internal organs, the former parts being so much farther away from the center of gravity than the latter.

Hunter (1774) thought that the air-spaces in the bones acted as air-reservoirs, and recently Grober (1899) and Madarász (1899) have propounded the view that the storing up of air that may be required for respiration during flight forms a special function of the air-sacs. Baer entertains a similar opinion. He believes that the bird breathes very differently during flight than when at rest, and that the whole air-sac system, the complete aëration of which, during repose, he has sought to prove both theoretically and experimentally, acts during the most strenuous corporeal efforts of the bird when flying merely as an air-reservoir. He says (1896, p. 487): "Nach allen diesen Erwägungen komme ich zu dem Schlusse, dass die Durchlüftung des Atemapparates während des Fluges in ganz anderer Weise erfolgen muss, als in der Ruhe oder bei der Bewegung auf festem Boden und es darf füglich angenommen werden, dass besondere Atembewegungen neben den Flügelbewegungen nicht ausgführt werden." Among these "Erwägungen" there is first of all the assertion (p. 486) that in man every great effort of the anterior extremity is accompanied by a more or less complete immobility of the thorax. This is indeed the case in movements occupying only a short time, as in lifting a weight (one of the examples mentioned by Baer), but not in movements of longer duration. A trained gymnast breathes during the most difficult exercise if it lasts long, only he so chooses the moment for making the respiratory movements that he thereby suffers no loss of power. An untrained gymnast, it is true, does not readily select such a moment, and therefore does not trust himself to breathe, and consequently is unable to endure so long a muscular strain. Why should we not assume that the flying bird has the ability of a good gymnast? A flying sky-lark by no means sings in the time of its wing-beats. These are rapid—about eight in a second—so that one can hardly see the moving wings. Nevertheless the sky-lark produces, during its flight, long-drawn and quite continuous notes, which in their perfectly constant intensity, show no trace of being composed of numerous short notes corresponding to the intervals between the wing-beats. Such would be the case, however, if the view of Baer, given above, which is shared by Campana and Strasser, were correct. But there is also another consideration which makes that opinion untenable. The only direct influence on the lungs and the air-sac system of the wing-movement during flight is the alternation of pressure exerted on the air-sac diverticula lying above and below the shoulder-joint. Every time the wings are raised the former, every time the wings are lowered the latter are compressed. As, however, both are diverticula of one and the same sac, this alternating compression of them caused by the wing-movement cannot produce any considerable air-current passing through the lungs. The air of the sac in question, the saccus interclavicularis, is merely agitated to and fro by this means. In this connection it must not be forgotten that, as Lendenfeld (1896, p. 777) has stated, the birds of great wing-power which possess the largest axillary and subpectoral diverticula are for the most part sailing fliers which often continue their flight for many minutes, even for half an hour and longer (Darwin, condor), without flapping their wings, so that in these even that slight air-movement in the air-sac system is interrupted for considerable spaces of time.

We will now consider the question of the utility afforded by the pneumaticity of the bones. It has been mentioned above that the walls of the air-sacs within the bones are very rich in blood-vessels, and consequently absorb oxygen and give off carbonic acid gas. Even if there were a marked difference of air-pressure at the times of inspiration and expiration in these spaces, the renewal of the air in them could only be effected very gradually on account of the unyielding character of their walls. The carbonic acid gas has, therefore, much time to collect in these spaces, and yet but little such gas can be demonstrated there. This shows how slight the blood oxidation is in pneumatic bones, and, further, that the function of the air-spaces in these bones cannot be a respiratory one.

Sappey (1846) remarked in this connection that the penetration of processes from air-sacs into bones enlarges their sectional area, and thereby increases their power of resistance without increasing their weight. Bergmann and Leuckart (1852, p. 235) ascribe a great significance to the reduction of specific gravity imparted to the skeleton by the pneumaticity of bones. Strasser (1877, p. 223) has treated this subject most thoroughly, and has succeeded in showing in the clearest manner that the utility of the pneumaticity of bones is purely a mechanical one. Most recent authors have accepted this interpretation; only P. Schulz (1896) holds a somewhat different view. Taking into consideration those birds of good flight, which, like the terns, possess no pneumatized bones, he thinks that the mechanical advantages of the pneumaticity cannot be so great as is assumed by many authors.

Conclusions

I do not consider the air-sacs, including the air-cavities of bones, as organs having a positive and special function, but rather as a system of empty interspaces. Their value lies in their emptiness—that is, in their containing nothing that offers resistance or has an appreciable weight.

Flying is the highest form of locomotion, and as such only possible to a body of high mechanical efficiency. Our most effective machines are by no means compact and solid, but composed of parts as strong as possible in themselves and arranged in the most appropriate manner. The interspaces between the parts are left empty and taken up by air.

The Sauropsida, at the time they obtained the power of flight, became adapted to its mechanical requirements, and thereby similar to the efficient machines mentioned above; they divested themselves of all superfluous material, filling the body-spaces thus obtained with air-sacs. While the body-wall, adapting itself to the mechanical requirement, became a compact, hollow cylinder serving as a support for the organs of movement, the mobility of the parts was assured by surrounding them with air-sacs.

The lengthening of the neck, produced by quite a different adaptation, made necessary an increase in the quantity of air moved during respiration. This demand was met by air-currents generated through a rhythmical change in the volume of the air-sacs. The connection of the air-sacs with the lungs is a consequence of their phylogenetic development, which is repeated in their embryological development, and has no physiological significance other than that the air-sacs assist in renewing the air in the trachea.

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EXPLANATION OF THE FIGURES

(PLATES XLV–XLIX)

FIG. 1. Transverse section of the thorax at the interspace between the 3d and 4th thoracic vertebræ.

FIG. 2. Transverse section of the thorax passing through the middle of the heart.

FIG. 3. Transverse section of the neck passing through a pair of transverse processes of a vertebra.

FIG. 4. Transverse section of the neck where the diverticula forming the supramedullary canal are given off from the two canales intertransversarii.

FIG. 5. Transverse section of the neck at a point where supravertebral diverticula are given off from the canales intertransversarii.

FIG. 6. Dorsal aspect of the pelvis after the removal of the skin.

FIG. 7. Frontal aspect of the anterior diverticulum of the interclavicular sac and the adjacent parts.

FIG. 8. Ventral aspect of the posterior part of the left lung.

FIG. 9. Ventral aspect of the left lung. (Photographed with prism, therefore a reversed picture. × 2.

FIG. 10. Dorsal aspect of the left lung after removal of its superficial portions. The lung has been injected with a dark-colored mass. A number of bronchial branches have been exposed by the dissection. (Photographed with prism, therefore a reversed picture.) × 2.

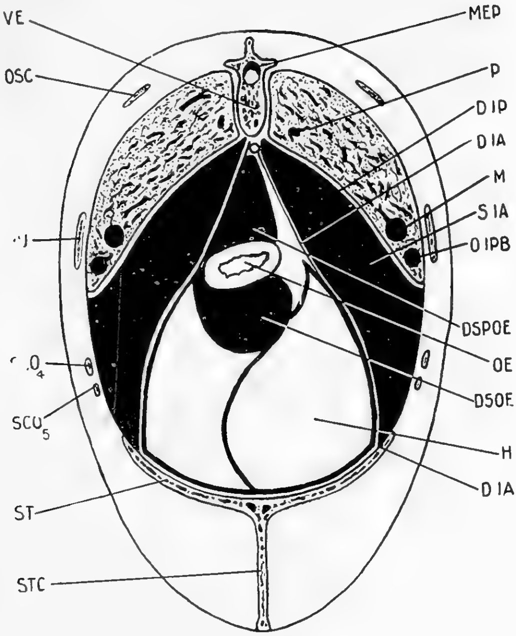
FIG. 11. View of the air-sacs that lie between the soft parts and the skeleton on the left side.

FIG. 12. Dorsal view of the air-sacs that lie between the soft parts and the lungs. (The latter are represented as transparent.)

AP	Arteria pulmonalis. Fig. 9.
BR	Bronchus. Figs. 9, 10, and 12.
C	Costal impressions on the lung. Fig. 10.
CF	Caput femoris. Fig. 6.
CI 1	Canalis intertransversarius, enlarged portion. Figs. 11 and 12.
CI 2	Canalis intertransversarius. Figs. 3, 4, 5, 7, 11, and 12.
CI 3	Canalis intertransversarius, anterior end. Figs. 11 and 12.
CO	Cavum orale. Fig. 12.
COR	Heart. Fig. 2.
COS	Rib. Figs. 2 and 5.
CPRA	Canalis præacetabularis. Figs. 11 and 12.
DA 1	Diverticulum axillare. Figs. 11 and 12.
DA 2	Ventral outgrowth of same. Fig. 11.
DC	Diverticulum costale. Figs. 2 and 11.
DFA	Diverticulum femorale anterius. Figs. 11 and 12.
DFI	Diverticulum femorale inferius. Figs. 11 and 12.
DFP	Diverticulum femorale posterius. Figs. 11 and 12.
DFS	Diverticulum femorale superius. Figs. 6, 11, and 12.

DIA	Diaphragma abdominalis. Fig. 1.
DIP	Diaphragma pulmonalis. Fig. 1.
DOETR	Diverticulum œsophageo-tracheale. Figs. 7 and 11.
DSC	Diverticulum subcordale. Fig. 2.
DSH	Diverticulum suprahumerale. Fig. 12.
DSOE	Diverticulum subœsophageale. Fig. 1.
DSPM 1	Diverticulum supramedullare (not in contact with that of the opposite side). Fig. 12.
DSPM 2	Diverticulum supramedullare (in contact with that of the opposite side). Figs. 11 and 12.
DSPOE	Diverticulum supra-œsophageale. Fig. 1.
DSPV	Diverticulum supravertebrale. Figs. 3, 4, 5, 7, 11, and 12.
DSSC 1	Diverticulum subscapulare, first portion. Figs. 7, 11, and 12.
DSSC 2	Diverticulum subscapulare, ventral outgrowth. Fig. 11.
DSSC 3	Diverticulum subscapulare, principal cavity. Figs. 2, 11, and 12.
DSSC 4	Diverticulum subscapulare, dorsal portion. Fig. 7.
DST	Diverticulum sternale. Figs. 2 and 11.
ECT	Ectobronchium primum ad septimum. Fig. 10.
ENT 1	Entobronchium primum. Fig. 10.
ENT 4	Entobronchium quartum. Fig. 10.
F	Furcula. Fig. 7.
FT	Foramen transversarii. Figs. 3, 4, and 7.
FTR	Foramen triosseum. Fig. 7.
H	Liver. Fig. 1.
L	Larynx. Fig. 12.
M	Mesobronchium. Figs. 1, 8, and 10.
ME	Medulla spinalis. Figs. 3, 4, 5, and 7.
MEA	Canalis supramedullaris, anterior portion. Figs. 3, 4, 5, 7, and 12.
MEP	Canalis supramedullaris, Posterior portion. Figs. 1, 2, and 12.
MF	Furcular membrane. Fig. 7.
MLC	Musculus levator coccygis. Fig. 6.
MP	Musculi Perraulti. Fig. 8.
OC	Ostium cervicale. Figs. 9, 10, and 12.
OCD	Os coracoideum. Fig. 7.
OCL	Ostium claviculare. Figs. 9 and 12.
OE	Œsophagus. Figs. 1, 2, 7, and 9.
OI	Os ischii. Fig. 6.
OIA	Ostium intermedium anterius. Figs. 9 and 12.
OIP	Ostium intermedium posterius. Figs. 8, 9, 10, and 12.
OIPB	Bronchial branch leading to the ostium intermedium posterius. Fig. 1.
OP	Ostium posterius. Figs. 8, 9, 10, and 12.
OS	Os sacrum. Fig. 6.
OSC	Scapula. Figs. 1 and 2.
P	Lung. Figs. 1, 2, 11, and 12.
PAR	Parabronchium. Fig. 10.
PAV	Processus articularis vertebræ. Fig. 7.
PL	Pleura. Fig. 9.
PU	Processus uncinatus. Fig. 1.
R	Kidney. Fig. 8.
S	Syrinx. Fig. 12.

SAD	Saccus abdominalis dexter. Figs. 6, 11, and 12.
SAS	Saccus abdominalis sinister. Figs. 6, 11, 12.
SASD	Dorsal wall of the left Saccus abdominalis. Fig. 8.
SC	Saccus cervicalis. Figs. 7 and 11.
SC 1	Saccus cervicalis, anterior portion. Fig. 12.
SC 2	Saccus cervicalis, pars ovalis. Fig. 12.
SCL	Saccus interclavicularis. Figs. 2, 11, and 12.
SCO 4	Os sternocostale quartum. Fig. 1.
SCO 5	Os sternocostale quintum. Fig. 1.
SI	Portion of the ventral surface of the lung covered by the Sacci intermedii, anterior and posterior. Fig. 9.
SIA	Saccus intermedius anterior. Figs. 1, 11, and 12.
SIAD	Dorsal wall of the Saccus intermedius anterior. Fig. 8.
SICL	Portion of the ventral surface of the lung covered by the Saccus interclavicularis. Fig. 9.
SIP	Saccus intermedius posterior. Figs. 11 and 12.
SIPD	Dorsal wall of the Saccus intermedius posterior. Fig. 8.
ST	Sternum. Figs. 1 and 2.
STC	Crista sterni. Figs. 1 and 2.
T	Entrance to trachea. Fig. 12.
TR	Trachea. Figs. 2, 7, 11, and 12.
V	Vestibulum. Fig. 10.
VE	Vertebra. Fig. 1.
VP	Vena pulmonalis. Fig. 9.
VPAN	Processus anterior vertebræ. Figs. 3 and 4.
VPP	Processus posterior vertebræ. Fig. 4.
X	Limiting wall between the Saccus interclavicularis and the Sacci intermedii anteriores. Fig. 8.
Y	Muscles of the neck. Fig. 7.



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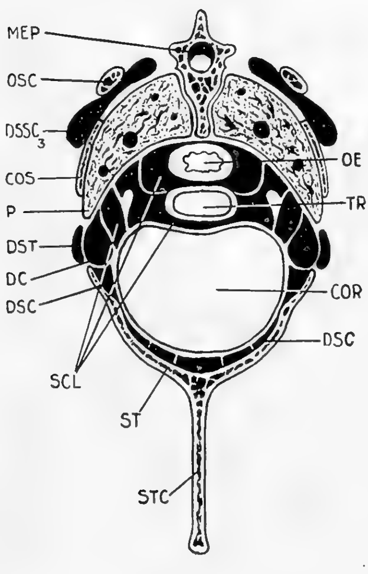

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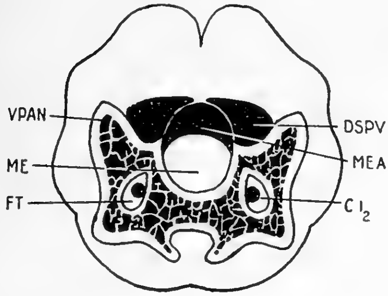
FIGS. 1, 2.—Transverse sections of thorax of pigeon. See page 412.



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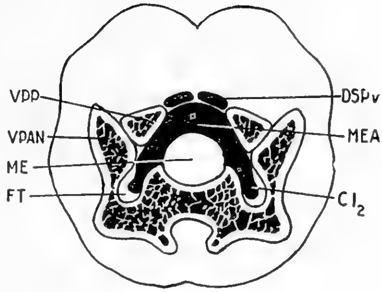

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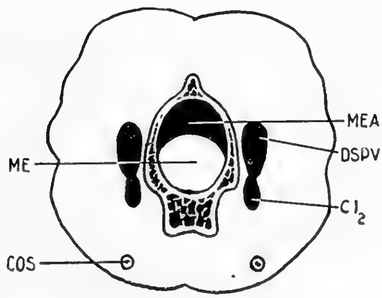

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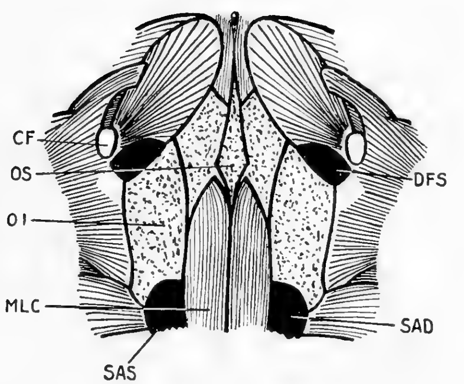
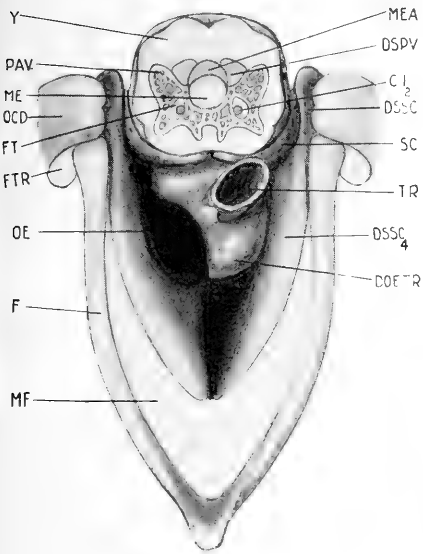


6

FIGS. 3, 4, 5.—Transverse sections of neck of pigeon. FIG. 6.—Dorsal aspect of pelvis. See page 412.



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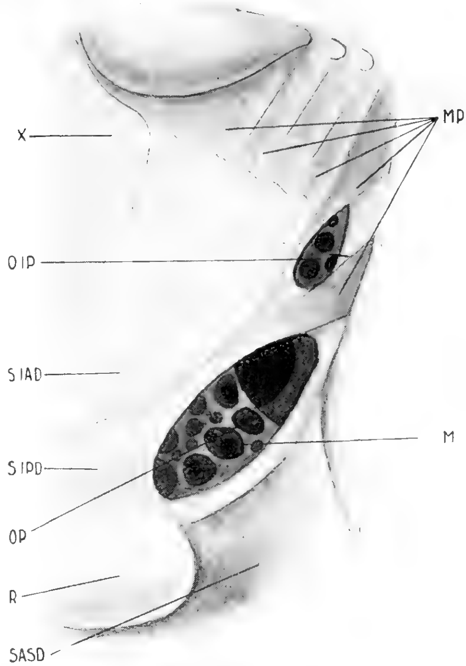

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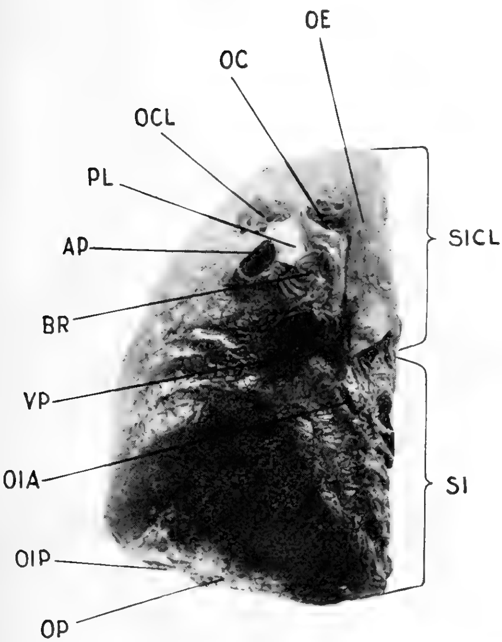

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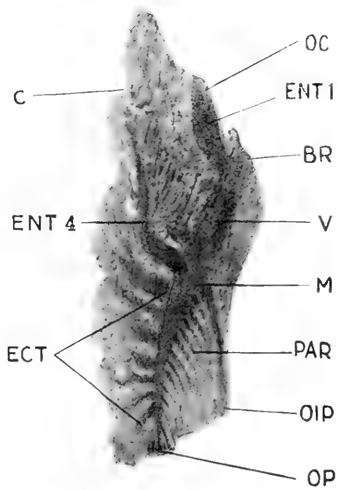

10

FIG. 7.—Anterior diverticulum of interclavicular sac. FIGS. 8, 9, 10.—Ventral and dorsal aspects of lung of pigeon. See page 412.


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D SPM 2
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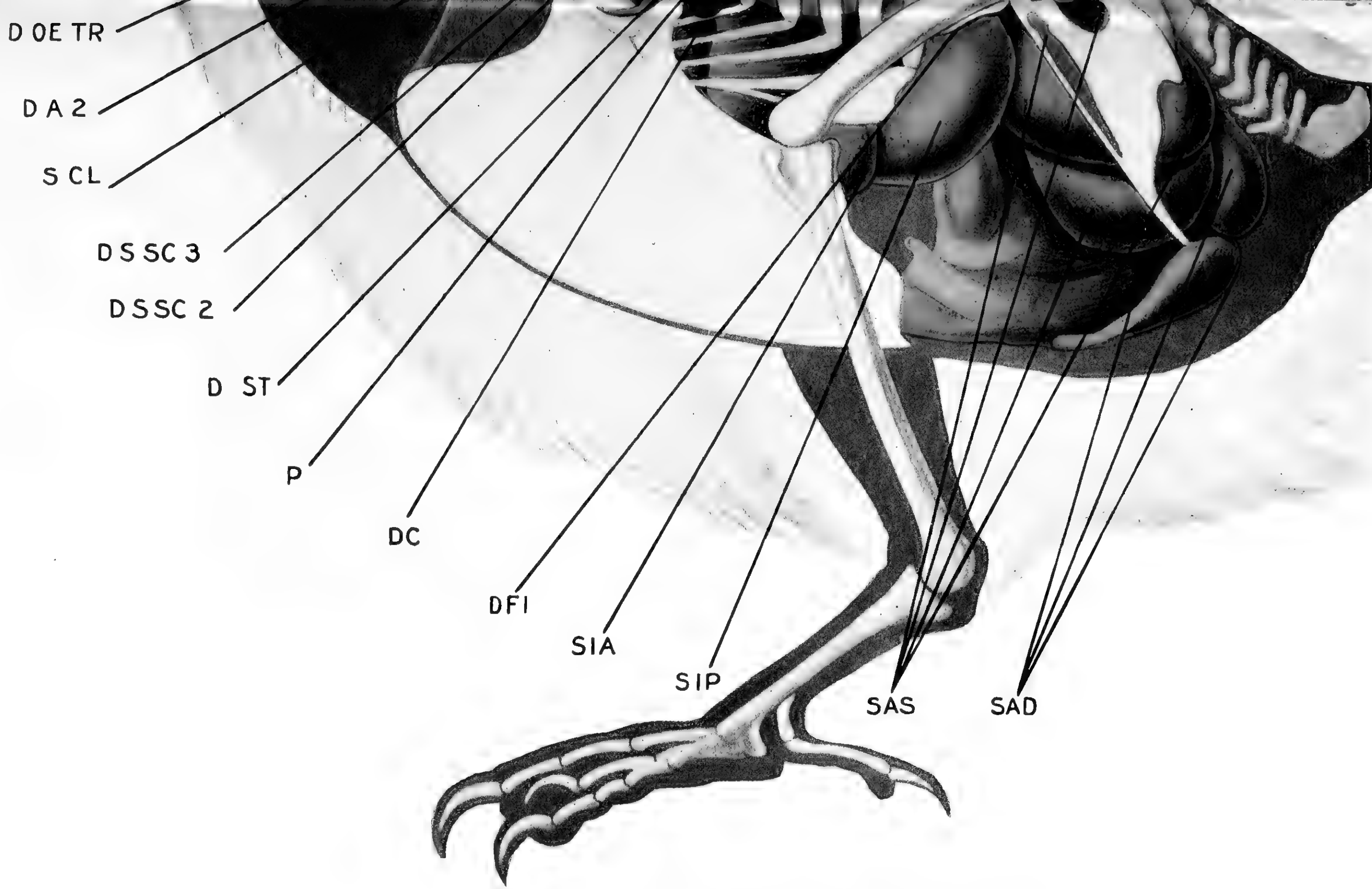
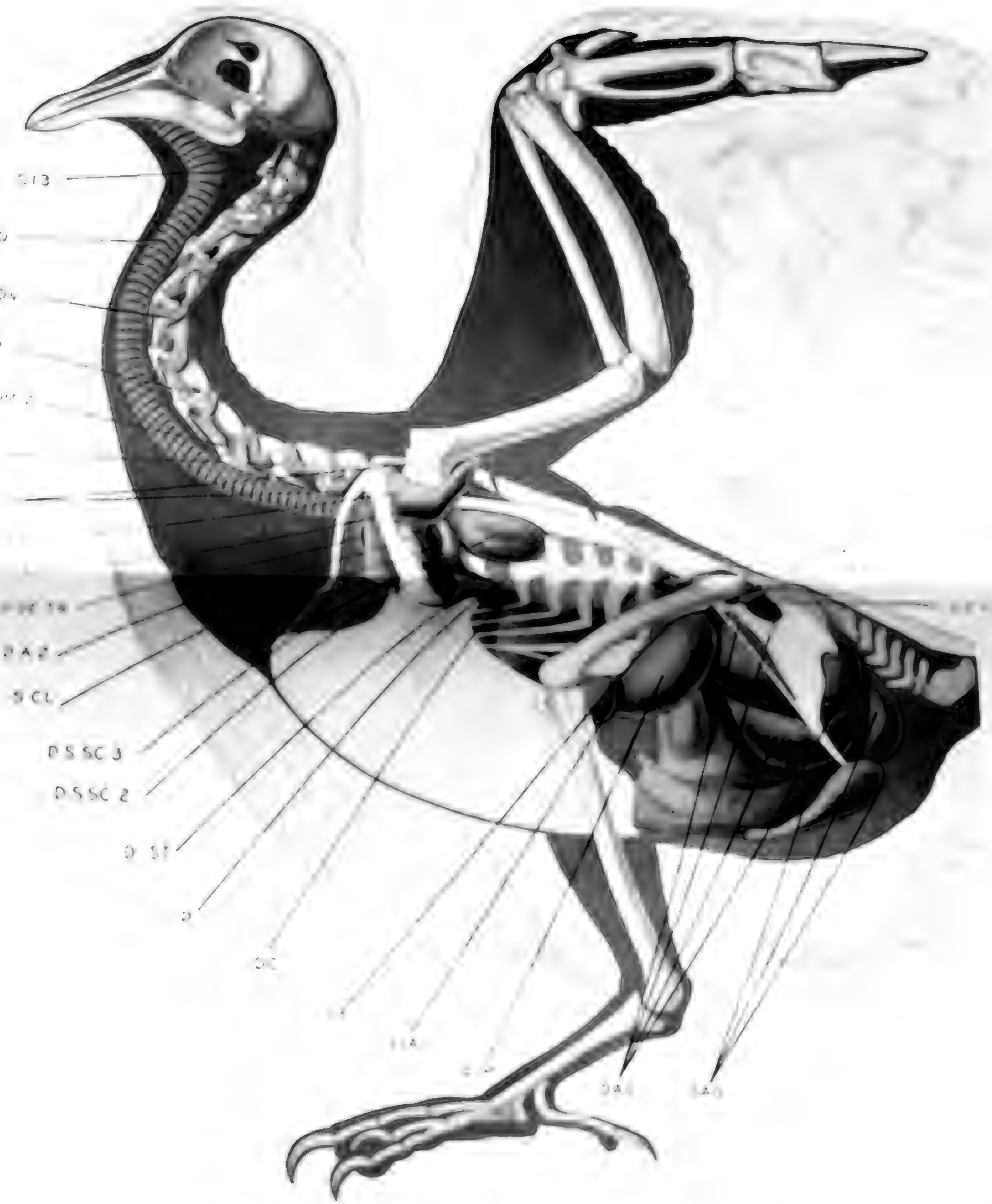
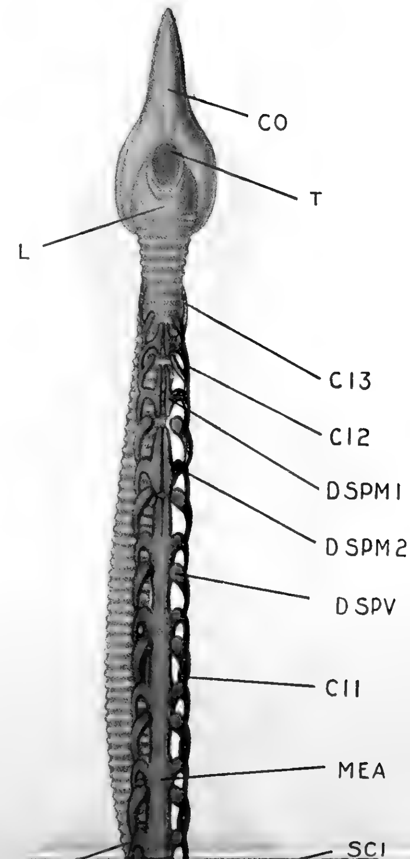


FIG. 11 VIEW OF THE AIR-SACS THAT LIE BETWEEN THE SOFT PARTS AND THE SKELETON ON THE LEFT SIDE.


D S SC 3
D S SC 2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SC1

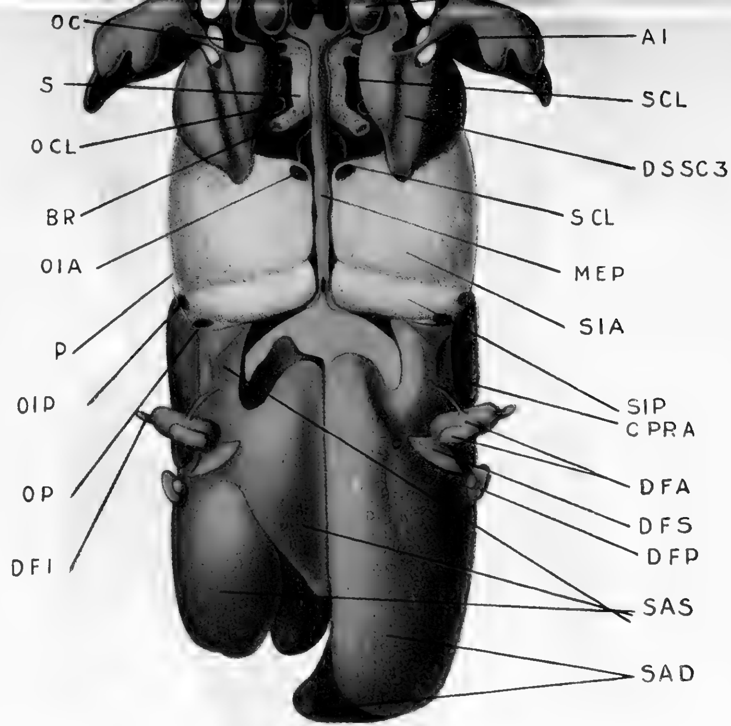
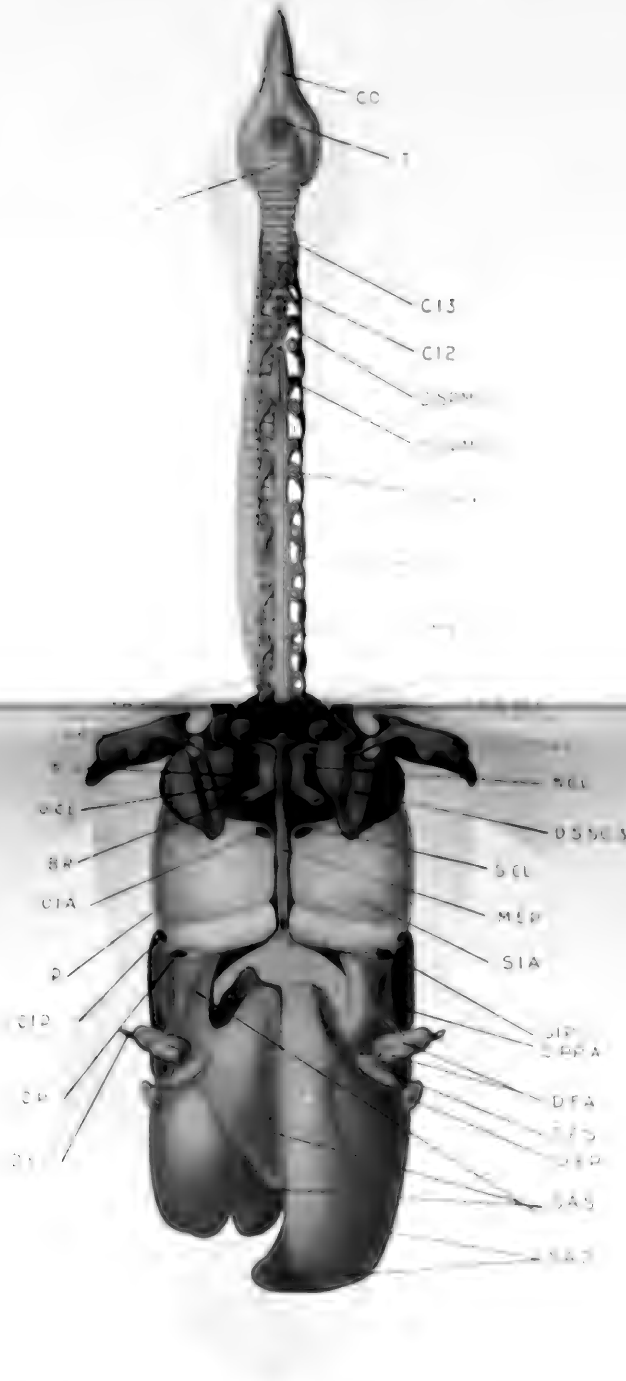


FIG. 12 DORSAL VIEW OF THE AIR-SACS THAT LIE BETWEEN THE SOFT PARTS AND THE LUNGS.
(THE LATTER ARE REPRESENTED AS TRANSPARENT).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NOTES

Congress of Orientalists

At the suggestion of the Smithsonian Institution, the Department of State has designated Prof. Paul Haupt, of Johns Hopkins University; Dr. C. R. Lanman, of Harvard University; Prof. Morris Jastrow, of the University of Pennsylvania, and Prof. A. V. W. Jackson, of Columbia University, to represent the United States at the Fifteenth International Congress of Orientalists to be held in Copenhagen in the latter part of August, 1908. Dr. Haupt, who is honorary associate in historic archeology in the National Museum, will represent the Smithsonian Institution and the National Museum.

Smithsonian Grants

Prof. E. L. Nichols, of Cornell University, who has been carrying on a research on the properties of matter at the temperature of liquid air, has received a further grant from the Institution to enable him to continue his work during the coming year.

A grant from the Smithsonian fund has recently been approved in behalf of Mr. F. L. Hess, of the U. S. Geological Survey, for the preparation of a bibliography of the literature on tin.

A grant has also been approved in behalf of Prof. William Hallock, of Columbia University, to make investigations of a physical nature in the well, 3,300 feet deep, of the Yough River Oil and Gas Company, near Oakland, Maryland.

The research on the flow of air through a nozzle for the purpose of determining the factors that make for efficiency in the production of liquid air, which has been carried on under the direction of Prof. W. P. Bradley, of Wesleyan University, has been brought to completion, and the results are being prepared for publication.

Mr. Bailey Willis, of the U. S. Geological Survey, who has spent some months in Europe, under a Smithsonian grant, investigating current theories regarding the structure of the Alps, has submitted a short preliminary report of his work. A full account of the investigation and the conclusions reached is in preparation.

The Upas Tree in the Philippines

The Smithsonian Institution has received a communication from Dr. E. D. Merrill, Chief of the Bureau of Botany at Manila, in which he makes the following reference to Dr. Berthold Laufer's paper, published in part 2 of the present volume of the Quarterly Issue.

"In the paper by Mr. Laufer on the relations of the Chinese to the Philippines, I find, on page 277, a reference to a statement by Verbiest (1673) regarding a tree in the Philippines that causes the death of those approaching it.

"The tree in question is the so-called 'Upas tree' of Malayan fables, *Antiaris toxicara,* regarding which the most fabulous accounts have been written, and which are admirably summarized by Robert Brown in Bennett, Brown and Horsefield, Plantæ Javanicæ Rariores, pp. 53-63, in English, while an extensive account of it is also given by Blume in Rumphia 1 : 56."

CHANGE OF NAME ETHELUMORIS TO ETHELOMORUS

In Dr. Harriet Richardson's paper on Terrestrial Isopods of the family Eubelidæ, published September 12, 1907, in part 2 of the present volume of the Quarterly Issue, an error of transcription was made by the author in the spelling of the genus name *Ethelomorus* (misspelled *Ethelumoris*). Inasmuch as this is equivalent to a typographical error, according to the rules in nomenclature it should be corrected and the spelling *Ethelomorus* adopted. The name is derived from the related genus *Ethelum* and the Greek ὅμορος, neighbor.—Harriet Richardson.

PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

CONTINUED FROM LIST IN QUARTERLY ISSUE, VOL. IV, PART 2

No.	*Title*	*Series*	*Price*
1736	Twenty-fifth Annual Report of the Bureau of American Ethnology, 1903-04		
1737	Report of the Secretary of the Smithsonian Institution for the year ending June 30, 1907	R. 1907	
1738	ABBOT, C. G., and FOWLE, F. E., JR. Annals of the Astrophysical Observatory, Vol. II. (*In press*)		
1739	Smithsonian Contributions to Knowledge, Vol. XXXIV. (*In press*)	C.K. XXXIV	
1740	Smithsonian Contributions to Knowledge, Vol. XXXV. (*In press*)	C.K. XXXV	
1741	Smithsonian Miscellaneous Collections, Vol. XLIX. (Contains Nos. 1584, 1652, 1717, 1720, 1721)	M.C. XLIX	
1742	Annual Report of the Smithsonian Institution for the year ending June 30, 1906	R. 1906	
1743	Proceedings of the Board of Regents, Report of Executive Committee, Acts of Congress, for the year ending June 30, 1906	R. 1906	
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1772	Smithsonian Miscellaneous Collections, *Quarterly Issue*, Vol. IV, Part 3 (containing Nos. 1724, 1773–1779)	M.C. L	.50
1773	FEWKES, J. WALTER. Excavations at Casa Grande, Arizona, in 1906-07 (*Quarterly Issue*)	M.C. L	.15
1774	ROSE, J. N. Nopalea guatemalensis, A New Cactus from Guatemala (*Quarterly Issue*)	M.C. L	.05
1775	BRITTON, N. L., and ROSE, J. N. Pereskiopsis, A New Genus of Cactaceæ (*Quarterly Issue*)	M.C. L	.05
1776	UNDERWOOD, LUCIEN M., and MAXON, WILLIAM R. Two New Ferns of the Genus Lindsaea (*Quarterly Issue*)	M.C. L	.05
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1778	CLARK, AUSTIN HOBART. New Genera of Recent Free Crinoids (*Quarterly Issue*)	M.C. L	.05
1779	Notes to *Quarterly Issue*, Vol. IV, Part 3	M.C. L	.05

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SMITHSONIAN

MISCELLANEOUS COLLECTIONS

VOL IV QUARTERLY ISSUE PART 4

NEW AND CHARACTERISTIC SPECIES OF FOSSIL MOLLUSKS FROM THE OIL-BEARING TERTIARY FORMATIONS OF SANTA BARBARA COUNTY, CALIFORNIA

By RALPH ARNOLD

Paleontologist, U. S. Geological Survey

Introduction

During an examination of the Santa Maria and Summerland oil districts, Santa Barbara County, California, by the writer, assisted by Robert Anderson and H. R. Johnson, in the summer of 1906, fossils were found representative of several geological horizons in the Tertiary. Many of these are well known or previously described species, but some of them are new forms. In the following paper several of the new forms are described and figured; while a few of those previously described are simply figured, and a brief note concerning their occurrence is inserted in the explanation accompanying each drawing. It has been deemed advisable to insert figures of the old species in this paper because the descriptions and illustrations of these forms are in publications inaccessible to most readers, and it is essential for the proper identification of the faunas that certain of the old species be known. The differentiation of the various geologic formations in the southern coast ranges of California depends almost entirely upon their paleontology, so that it has been the aim of the writer to give in this paper some of those species which will aid in the determination of the horizon of the various faunas found in that region. These fossils, together with some others, will be figured on plates IX to XVII, Bulletin 321, and plates XII to XXVI, Bulletin 322, U. S. Geological Survey.

The new Eocene forms, *Turritella* (*martinezensis* Gabb, var. ?), *lompocensis*, and *Pecten yneziana*, are from the brownish sandstone of the Tejon formation which makes up a considerable portion of the Santa Ynez Range south of Lompoc and Santa Ynez. Within this formation in the territory mentioned are found the following fossils:

LIST OF EOCENE (TEJON FORMATION) FOSSILS FROM WESTERN END OF SANTA YNEZ RANGE

(Those marked "a" are found at locality No. 4507, just above the San Julian ranch house about 10 miles southeast of Lompoc, the type locality of *Pecten yneziana;* those marked "b" are found at locality No. 4509, a float boulder found in sharp turn in road in San Miguelito Canyon, 4½ miles southwest of Lompoc, the type locality of *Turritella* (*martinezensis* Gabb, var.?) *lompocensis.*)

Cardium brewerii Gabb [a].
Codakia (?) species [a].
Conus cf. *hornii* Gabb.
Crassatellites collina Conrad [a b].
Dosinia elevata Gabb [a].
Fusus occidentalis Gabb [a].
Ficus mammillatus Gabb [a].
Glycymeris cf. *veatchii* Gabb, var. *major* Stanton [a b].
Mactra cf. *uvasana* Conrad.
Meretrix uvasana Conrad [a].
Meretrix, species.
Neverita ? species.
Nucula truncata Gabb.
Ostrea idriænsis Gabb [a].
Pecten (*Chlamys*) *yneziana*, new species [a b].
Phacoides cumulata Gabb.
Phacoides (*Miltha?*), species [a].
Tellina (?), species.
Turritella (*martinezensis* Gabb, var.?) *lompocensis*, new variety [a].
Turritella uvasana Conrad [a].
Venericardia planicosta Lamarck [a].

The lower Miocene or Vaqueros formation is stratigraphically above, but closely associated with, the Tejon, and consists largely of coarse conglomerate and sandstone, with some associated limestone near the top. The new species, *Purpura vaquerosensis, Pecten vanvlecki,* and *Modiolus ynezianus,* are from the sandstone portion. Associated with the above forms in the Vaqueros formation, in the western end of the Santa Ynez Range, are the following species:

List of Lower Miocene (Vaqueros Formation) Fossils from Western End of Santa Ynez Range

(Those marked "a" are from locality No. 4504, three-fourths of a mile up ridge northeast of San Julian ranch house, 10 miles southeast of Lompoc, the type locality of *Modiolus ynezianus;* those marked "b" are from locality No. 4478, 2 miles south of Santa Ynez, on knoll just east of mouth of Ballard Canyon, the type locality of *Pecten vanvlecki.*)

Balanus cf. *estrellanus* Conrad.
Cardium aff. *quadrigenarium* Conrad [a].
Chione cf. *mathewsonii* Gabb.
Conus, species.
Crassatellites, species.
Meretrix (?) species.
Modiolus ynezianus, new species [a].
Mytilus cf. *mathewsonii* Gabb.
Ostrea eldridgei Arnold [a b].
Ostrea, new species, near *titan* Conrad [a].
Pecten (*Pecten*) *vanvlecki,* new species [b].
Pecten (*Lyropecten*) *bowersi* Arnold.
Pecten (*Lyropecten*) *crassicardo* Conrad.
Pecten (*Amusium*) *lompocensis* Arnold.
Pecten (*Lyropecten*) *magnolia* Conrad [a b].
Pecten (*Chlamys*) *sespeensis,* var. *hydei* Arnold [b].
Purpura vaquerosensis, new species.
Solen, species.
Terebratalia kennedyi Dall.
Turritella, species indeterminate.
Turritella ineziana Conrad.
Turritella variata Conrad (young).

The Fernando formation in the Santa Maria district is widespread, and consists largely of soft shale, sandstone, and more or less incoherent conglomerate, usually resting unconformably above the Monterey or middle Miocene shale. The most fossiliferous localities appear to represent a fauna of lower Pliocene age, although the formation as a whole is believed to extend down into the upper Miocene and upward into the Pleistocene.

The following new species and varieties are described from the Fernando formation in the Santa Maria district, all of the localities being north of the Santa Ynez River:

List of New Species and Varieties of Fossils from the Fernando Formation (Largely Lower Pliocene), Santa Maria District

Lymnæa alamosensis, new species.
Drillia graciosana, new species.
Drillia waldorfensis, new species.
Bathytoma carpenteriana Gabb, var. *fernandoana,* new variety.

Cancellaria crawfordiana Dall, var. *fugleri,* new variety.
Nassa waldorfensis, new species.
Ocinebra micheli Ford, var. *waldorfensis,* new variety.
Leda orcutti, new species.
Phacoides nuttallii Conrad, var. *antecedens,* new variety.
Spisula catilliformis Conrad, var. *alcatrazensis,* new variety.
Spisula sisquocensis, new species.

Associated with these at the various localities are the following (mostly previously described) species:

Partial List of Fernando (Upper Miocene-Pliocene-Pleistocene) Fossils from the Santa Maria District

Actæon, species.
Amphissa (?) species.
Angulus, species.
Arca, species [a].
Arca, species indeterminate.
Arca trilineata Conrad.
Astyris richthofeni Gabb.
Balanus cf. *concavus* Bronn.
Bathytoma cf. *tryoniana* Gabb.
Bittium, new species [a].
Bittium, new species [c].
Cadulus fusiformis Sharp and Pilsbry.
Calliostoma, species indeterminate.
Callista subdiaphana Carpenter.
Cancellaria, species.
Cardium meekianum Gabb.
Cardium, species indeterminate.
Chione, species.
Chlorostoma (?) species.
Chrysodomus, species.
Clidiophora punctata Carpenter.
Crepidula princeps Conrad.
Crucibulum spinosum Sowerby.
Cryptomya ovalis Conrad.
Cumingia californica Conrad.
Dosinia ponderosa Gray.
Drillia johnsoni Arnold.
Echinarachnius ashleyi Merriam.
Echinarachnius cf. *excentricus* Eschscholtz, var.[a].
Fusus, species [a].
Fusus, species [b].
Galerus inornatus Gabb.
Glycymeris cf. *barbarensis* Conrad.
Kennerlia (?) species.
Leda taphria Dall.
Lucapina cf. *crenulata* Sowerby.
Lunatia lewisii Gould.

Macoma nasuta Conrad.
Macoma, species.
Macoma cf. *secta* Conrad.
Mactra, species.
Miopleiona oregonensis Dall.
Modiolus rectus Conrad.
Monia macroschisma Deshayes.
Muricidea, species.
Mya truncata Linné.
Mytilus, species indeterminate.
Nassa californiana Conrad.
Natica clausa Broderip and Sowerby.
Neverita recluziana Petit.
Ocinebra lurida Middendorf.
Olivella biplicata Sowerby.
Olivella cf. *intorta* Carpenter.
Opalia anomala Stearns.
Opalia varicostata Stearns.
Ostrea veatchii Gabb.
Ostrea possibly *veatchii* Gabb.
Panomya cf. *ampla* Dall.
Panopea generosa Gould.
Pecten (*Plagioctenium*) near *cerrosensis* Gabb.
Pecten (*Patinopecten*) *healeyi* Arnold.
Pecten (*Pecten*) *hemphilli* Dall.
Pecten (*Chlamys*) *lawsoni* Arnold.
Pecten (*Patinopecten*) *oweni* Arnold.
Pecten (*Pecten*) *stearnsii* Dall.
Pecten (*Chlamys*) *wattsi* Arnold.
Phacoides annulatus Reeve.
Phacoides intensus Dall.
Pholadidea ovoidea Conrad.
Pholadidea (?) species indeterminate.
Platyodon cancellatus Conrad, var. [a].
Pleurotoma (*Borsonia*), species [a].
Pleurotoma, species.
Priene oregonensis Redfield, var. *angelensis* Arnold (?)
Priene oregonensis Redfield (young).
Purpura crispata Chemnitz.
Saxidomus gracilis Gould.
Saxidomus (?) species [a].
Scala, species [a].
Sigaretus debilis Gould.
Siliqua cf. *edentula* Gabb.
Solen cf. *sicarius* Gould.
Tapes cf. *lacineata* Carpenter.
Tapes staleyi Gabb.
Tapes tenerrima Carpenter.
Tellina, species.
Tellina aff. *bodegensis* Hinds.
Terebratalia occidentalis Dall.

Thalotia caffea Gabb.
Thracia cf. *trapezoides* Conrad.
Thyasira aff. *gouldii* Philippi.
Tresus nuttallii Conrad.
Tritonium, species indeterminate.
Trochita radians Lamarck.
Trochita, species indeterminate.
Turritella cooperi Carpenter.
Venericardia californica Dall.

The Fernando formation in the vicinity of Santa Barbara consists of a series of conglomerate, sandstone, shale, and marl. The fossiliferous layers are largely sandstone and sandy marl (some of the latter made up almost entirely of bryozoan remains), and represent the Pliocene or possibly the lowest Pleistocene. The following new species and varieties are from the Fernando bryozoan marl at the bath-house beach, Santa Barbara:

Mitramorpha filosa Carpenter, var. *barbarensis*, new variety.
Puncturella delosi, new species.
Venericardia yatesi, new species.
Psephidia barbarensis, new species.

Associated with the above in the same locality are the following previously described or questionable species:

PARTIAL LIST OF FERNANDO (PLIOCENE OR LOWEST PLEISTOCENE) FOSSILS FROM BATH-HOUSE BEACH, SANTA BARBARA

Acmæa insessa Hinds.
Admete gracilior Carpenter.
Amphissa corrugata Reeve.
Balanus concavus Bronn.
Bela fidicula Gould.
Bittium barbarensis Bartsch.
Bittium catalinensis Bartsch.
Bryozoa, species.
Cardium corbis Martyn.
Calliostoma gemmulatum Carpenter.
Chrysodomus tabulatus Baird.
Clathurella conradiana Gabb.
Columbella (Astyris) gausapata Gould.
Columbella (Astyris) gausapata, var. *carinata* Hinds.
Columbella (Astyris) tuberosa Carpenter.
Crepidula adunca Sowerby.
Crepidula navicelloides Nuttall.
Crepidula princeps Conrad.
Cythara branneri Arnold.
Diastoma, species.
Fusus robustus Trask.

Galerus mammilaris Broderip.
Glottidia albida Hinds.
Lacuna compacta Carpenter.
Laqueus jeffreysi (?) Dall.
Leptothyra bacula Carpenter.
Leptothyra paucicostata Dall.
Macoma, species.
Mangilia angulata Carpenter.
Mangilia interfossa, var. *pedroana* Arnold.
Mangilia tabulata Carpenter.
Margarita pupilla Gould.
Mercenaria perlaminosa Conrad.
Modiolus fornicatus Carpenter.
Nassa mendica Gould.
Nassa perpinguis Hinds.
Natica clausa Broderlip and Sowerby.
Ocinebra barbarensis Gabb.
Ocinebra lurida Middendorf.
Ocinebra lurida, var. *aspera* Baird.
Ocinebra perita Hinds.
Odostomia nuciformis, var. *avellana* Carpenter.
Odostomia gouldii Carpenter.
Olivella biplicata Sowerby.
Panopea generosa Gould.
Pecten (*Pecten*) *bellus* Conrad.
Pecten (*Patinopecten*) *caurinus* Gould.
Pecten (*Chlamys*) *hastatus* Sowerby.
Pecten (*Chlamys*) *hastatus* Sowerby, var. *strategus* Dall.
Pecten (*Chlamys*) *jordani* Arnold.
Pecten (*Chlamys*) *opuntia* Dall.
Phacoides annulatus Reeve.
Phacoides californica Conrad.
Pododesmus macroschisma Deshayes.
Protocardia centifilosa Carpenter.
Puncturella cuculata Gould.
Semele pulchra Sowerby, var. *montereyi* Arnold.
Strongylocentrotus purpuratus Stimson.
Terebratalia hemphilli Dall.
Tornatina culcitella Gould.
Trophon (*Boreotrophon*) *gracilis* Perry.
Trophon (*Boreotrophon*) *orpheus,* var. *præcursor* Arnold.
Trophon (*Boreotrophon*) *stuarti* Smith.
Turbonilla tridentata Carpenter.
Venericardia monilicosta Gabb.

NEW EOCENE (TEJON FORMATION) SPECIES AND VARIETIES

TURRITELLA (MARTINEZENSIS Gabb, var. ?) LOMPOCENSIS, new variety

Pl. LI, figs. 5*a*, 5*b*, and 8.

DESCRIPTION.—Shell averaging about 80 millimeters in altitude, turreted, slender; apex acute. Whorls 10 or more, angulated near base, upper portion flat or slightly convex, lower concave. Suture appressed, not very distinct. Sculpture consists of a prominent raised revolving line on angle, another equally as important at the anterior margin and 3 others of varying degrees of importance above the angle; between these 5 principal lines there are sometimes intercalaries, the type showing a persistent one between the angle and the next line above; fine sharp incremental lines, some more important than others, cross the whorls, bowing convexly backward, this system of sculpture associated with the spiral lines, often giving the surface a cancellate appearance; the interspaces between the major spiral lines are of approximately the same width except in the case of the ones between the second and third lines above the angle, and between the third line above the angle and the suture, both of which are about two-thirds the width of the major interspaces.

DIMENSIONS.—Altitude of type, from which four or five upper whorls are gone, 68 mm.; latitude, 20 mm.

NOTES.—This variety is much slenderer than the typical form, and has the angle relatively nearer the base. Named for the town of Lompoc, near the type locality.

TYPE.—Cat. No. 165,316, U. S. N. M.

LOCALITY.—Float boulder, sharp turn in road in San Miguelito Canyon, 4½ miles southwest of Lompoc, Santa Barbara County, Cal.; locality No. 4509.

HORIZON.—Tejon formation, Eocene

PECTEN (CHLAMYS ?) YNEZIANA, new species

Pl. L, fig. 4, and Pl. LI, figs. 6*a* and 6*b*

DESCRIPTION.—Shell averaging 60 to 70 millimeters in altitude; slightly higher than long, moderately convex, practically equivalve and equilateral, rather thin; base regularly rounded; dorsal margins concave; margins somewhat serrate. Surface of disk onamented by from 30 to 45 irregular, inequidistant rounded, more or less imbricated ribs; in some instances the ribs occur quite regularly, every alternate one being prominent, with lesser ones (appearing as intercalaries) between; in others the ribs are irregularly disposed, although there is a tendency for the alternate ones to be larger and sometimes dichotomous. Ears radially striate in addition to incremental imbricating sculpture; anterior ear of right valve with deep byssal notch and well isolated byssal area.

Dimensions.—Latitude (restored) 75 mm.

Notes.—The imperfect fragments which furnish the characters described above represent a species apparently allied to *P. perrini* Arnold, although it is smaller and has more numerous and less imbricate ribs than the latter. *P. yneziana* is the only species of this group found in the Eocene. It has been recognized in the Tejon formation throughout the whole length of the Santa Ynez Range, and as far east as the Ojai Valley, Ventura County.

Type.—Cat. No. 165,313, U. S. N. M. Paratype, same number.

Locality.—San Julian ranch, 10 miles southeast of Lompoc, Santa Barbara County, California; locality No. 4507.

Horizon.—Tejon formation, Eocene.

New Lower Miocene (Vaqueros Formation) Species

PURPURA VAQUEROSENSIS, new species

Pl. LII, figs. 1*a* and 1*b*

Description.—Shell averaging about 100 millimeters in altitude, very broadly spindle-shaped, spire elevated, conical; apex subacute. Whorls 4 or 5, sharply angulated anteriorly immediately adjacent to suture, portion posterior to angle flat except for a slight concavity just in front of suture caused by bending back of posterior margin where it appresses against antecedent whorl. Suture appressed, wavy, distinct, sometimes encroaching on angle of posterior whorl. Sculpture of the penultimate and preceding whorls confined to fine backward-sloping incremental lines and sometimes a faint suggestion of nodes on the angle; body whorl biangulate, the posterior angle being the more prominent owing to a row of prominent nodes (10 in type), some of which are quite regular, some more or less spirally elongate, and others approaching the importance of spines, anterior angle consisting of a rounded spiral ridge and below this four other similar revolving ridges, separated by impressed lines; area between the two angles flat or slightly convex and carrying four obsolete spiral ridges; whole surface of whorl crossed by sharp imbricating lamellæ, which slope backward on posterior portion of whorl and rise to the importance of imbricating spines on the second and fourth ridges in front of anterior angle and occasionally on the other ridges.

Columella twisted and recurved, the lower portion overlapping a narrow canal; columella strongly sculptured by incremental lines. Aperture ovate; outer lip simple.

DIMENSIONS.—Altitude, 100 mm.; latitude, 68 mm.; altitude of body whorl, 92 mm.; longitude of aperture, including canal, 80 mm.

NOTES.—In all of the specimens of this species examined the aperture and the greater part of the columella are unfortunately concealed. It appears, however, from external characteristics to belong to the genus *Purpura,* and to that group of the genus represented by *P. tricercalis* Blainville and *P. triangularis Blainville,* although *P. vaquerosensis* is very much larger than either of the latter. This magnificent species is known in the lower Miocene from Monterey County south to Santa Barbara County, and is, so far as the writer is aware, confined to this one horizon of the Miocene. It is one of the prominent members of the very characteristic fauna of which *Pecten magnolia* Conrad, *Turritella ineziana* Conrad, and *Cardium,* new species near *quadrigenarium,* are a part. Named for the Vaqueros formation (lower Miocene), of which it is believed to be characteristic.

TYPE.—Collection of Delos Arnold, Pasadena, California.

LOCALITY.—Lynch Mountain, Monterey County, California.

HORIZON.—Vaqueros formation, lower Miocene.

PECTEN (PECTEN) VANVLECKI, new species

Pl. LIII, figs. 1 and 2

DESCRIPTION.—Shell averaging about 70 millimeters in altitude, length and height about equal, outline circular; both valves convex, the right slightly more so than the left, equilateral, thin; base regularly rounded; sides only very slightly concave above; margins smooth. Right valve somewhat convex, the region of greatest convexity being just below the beak; surface ornamented with 13 or 14 rather prominent ribs, these being quite rounded in the younger stages of growth, but gradually becoming flatter and lower toward the periphery; interspaces rounded near umbos, but shallower and flatter below; equal, fine, sharp, raised incremental lines, separated by interspaces as wide as the lines, cover the surface of the disk and ears; hinge line longer than half length of disk; ears subequal, anterior with shallow byssal notch; posterior rectangularly truncated. Left valve slightly less convex than right, flat to concave immediately below umbo; ribs regularly rounded throughout entire length, becoming flatter and sometimes almost obsolete toward the periphery; minute sculpture as in right valve; ears flat, the anterior one showing two or three faint radial riblets. Interior of both valves reflecting the external ribbing very prominently.

DIMENSIONS.—Longitude, 70 mm.; altitude, 64 mm.; diameter (approximate), 12 mm.

NOTES.—This species appears to be most closely related to *P. sanctæcruzensis* Arnold, which occurs in the Oligocene and lowest Miocene of the Santa Cruz Mountains. It is distinguishable from the latter by its larger size, flatter disks, less elevated ribs, and by the prominent reflection of the external ribbing on the interior of the disk. This last is one of the most prominent, unique, and interesting characteristics of *P. vanvlecki.* Named in honor of Mr. Robert Van Vleck Anderson, of the United States Geological Survey.

TYPE.—Cat. No. 165,305, U. S. N. M. (right valve).

PARATYPE.—Cat. No. 165,306, U. S. N. M. (left valve).

LOCALITY.—Mouth of Ballard Canyon, 2 miles south of Santa Ynez, Santa Barbara County, California; locality No. 4478.

HORIZON.—Vaqueros formation, lower Miocene.

MODIOLUS YNEZIANUS, new species

Pl. LII, fig. 2

DESCRIPTION.—Shell averaging about 60 millimeters in altitude, elongate-ovate in outline, convex, equivalve; beaks nearly terminal, protruding forward and slightly beyond margin; base not regularly rounded, curving sharper anteriorly; anterior margin curving sharply around attenuate extremity just in front of beak, and then straight for nearly entire length of shell, with the exception of a slight contraction near middle caused by a sulcation extending obliquely backward from beaks; posterior dorsal margin straight, bending around a moderately angular extremity into the slightly arcuate ventral margin; the shell bulges in the middle in such a way as to suggest a broad, rounded ridge bowing over obliquely backward from the anterior part of the base to the beak; surface sculpture consists of fine incremental lines.

DIMENSIONS.—Of type, a small specimen; altitude, 31 mm.; latitude, 18 mm.; diameter, 11 mm.

NOTES.—This species is allied to *M. fornicatus* Carpenter, from which it differs by being much larger, more angular posteriorly, not as ventricose nor with the bulging part as overturned posteriorly. It is quite abundant at the type locality and at other places where the Vaqueros formation is fossiliferous. Named for the Santa Ynez Mountains.

TYPE.—Cat. No. 165,324, U. S. N. M.

LOCALITY.—San Julian ranch, 10 miles southeast of Lompoc, Santa Barbara County, California; locality No. 4504.

HORIZON.—Vaqueros formation, lower Miocene.

NEW PLIOCENE (FERNANDO FORMATION) SPECIES AND VARIETIES

LYMNÆA ALAMOSENSIS, new species

Pl. LIV, figs. 6 and 7

DESCRIPTION.—Adult shell averaging about 6 or 7 millimeters in altitude, broadly spindle-shaped, spire elevated, apex rounded. Whorls four, bulging, more convex posteriorly than anteriorly; outline of body whorl regularly arcuate; a faint ridge crowns the posterior margin of each whorl where it appresses against the antecedent whorl. Suture appressed, slightly sinuous, distinct; sculpture consisting of numerous microscopic incremental lines, which are somewhat better developed on the posterior portion of the whorl, and occasional faint spiral striæ; a hard, glossy epidermis is preserved on some of the specimens. Aperture sub-oval, narrowing posteriorly; outer lip protruding anteriorly, thickened into overhanging flange internally, and flaring from posterior extremity as far around as umbilical region; a minute umbilical chink is visible in most specimens.

DIMENSIONS.—Altitude, 6 mm.; latitude, 3 mm.; altitude of body whorl, 4.9 mm.; longitude of aperture, 3 mm.; latitude of aperture, 1.5 mm.

NOTES.—This unique little fossil occurs in a peculiar fine-grained gray clay in the upper portion of the Fernando formation, where, at the type locality, near Los Alamos, it is quite abundant. No other fresh-water species were found associated with it.

TYPE.—Cat. No. 165,426, U. S. N. M.

LOCALITY.—Fresh-water beds one mile southeast of bench-mark 425, Los Alamos Valley, Santa Barbara County, California; locality No. 4483.

HORIZON.—Fernando formation, fresh-water portion at top, which probably corresponds with the Paso Robles formation of the San Luis quadrangle described by Fairbanks in the San Luis folio.

DRILLIA GRACIOSANA, new species

Pl. LIV, fig. 18

DESCRIPTION.—Shell averaging about 14 or 15 millimeters in altitude, spindle-shaped; the sharper portion of the spindle being above;

apex subacute. Whorls 5, somewhat angulated medially, convex anteriorly, concave to flat posteriorly, sculpture consisting of not very prominent rounded axial ribs (17 on penultimate whorl), obsolete above angle, and 2 spiral ridges of about equal importance to the axial ribs, also below the angle, these two systems giving a characteristic cancellated appearance to the surface; the upper margin of each whorl is appressed against the anterior portion of the one preceding and bent back into a little, more or less nodose revolving ridge next to suture; the area between this revolving ridge and the angle of the whorl is ornamented only by lines of growth which bow convexly posteriorly; the axial ridges become almost obsolete or are replaced by irregular lines of growth on the body whorl, while the spiral ridges (of which there are 7) become quite prominent, and are separated by channeled interspaces equal in width to the ridges. Suture appressed, wavy, and not very distinct. Columella curved, short and broad, faintly biangularly plicated and with a faint indication of an umbilical chink between it and the incrusted inner lip. Aperture subpyriform; notch rather prominent, though quite shallow; canal short and curved.

Dimensions.—Altitude, 14 mm.; latitude, 6 mm.; altitude of body whorl, 8.8 mm.; longitude of aperture, 4.5 mm.; latitude of aperture, 2 mm.; canal, 1.7 mm.

Notes.—This stubby little species is more closely related to *D. cancellata* Carpenter than to any other West Coast form, but is easily distinguishable from the latter by its broader outline, heavier shell, broader columella, fewer and stronger ribs and ridges. A species similar if not identical to *D. graciosana* is found in the San Diego formation at Pacific Beach, San Diego County. Named for Graciosa Ridge, the type locality.

Type.—Cat. No. 165,309, U. S. N. M.

Locality.—Graciosa Ridge, near Folsom well No. 5, Orcutt, Santa Barbara County, California; locality No. 4476.

Horizon.—Fernando formation, Pliocene portion.

DRILLIA WALDORFENSIS, new species

Pl. LIV, fig. 12

Description.—Shell averaging about 18 to 20 millimeters in altitude, slender, spindle-shaped; apex subacute when perfect. Whorls 8 or 9, convex, prominently angulated slightly anterior to middle; portion of whorl posterior to angle has a decidedly concave aspect, which is heightened by a tendency of the posterior margin of the whorl (which is appressed against the preceding whorl) to bend outward, sculpture consisting of obliquely forward sloping, broad, rounded axial ribs (10 on the penultimate whorl of the type), which are elevated into nodes on the angle, but become obsolete toward the sutures, especially posteriorly, where the whorl is almost free from axial ornamentation; spiral sculpture almost obsolete, although faint traces of spiral lines are sometimes visible between the ribs and on the anterior portion of the body whorl; faint lines of growth, still more oblique than the ribs, are visible, especially on the body whorl. Suture distinct, appressed, occasionally slightly undulating. Columella twisted at base and biangularly plicated. Aperture subpyriform; canal relatively long for this genus, slender, and strongly recurved; notch of medium prominence; inner lip straight, incrusted, with a decided callus at posterior end of aperture.

DIMENSIONS.—Altitude, 18.5 mm.; latitude, 6 mm.; altitude of body whorl, 10 mm.; longitude of aperture, 4 mm.; latitude of aperture, 2.1 mm; canal, 3.4.

NOTES.—This beautiful little *Drillia* appears to be more closely related to *D. empyrosia* Dall than to any other West Coast form, although its nodose whorls suggest *D. torosa* Carpenter at first sight. It is distinguishable from *D. empyrosia* by its smaller size, slenderer form, more recurved canal, and obsolete spiral sculpture (*D. empyrosia* being quite prominently spirally sculptured, especially on the body whorl). The recurved canal, oblique ribs, and slenderer form of *D. waldorfensis* separate it at once from *D. torosa. D. waldorfensis* reminds one of *D.* (*Cymotosyrinx*) *æpynota,* var. *acila* Dall, from the Shell Creek, Florida, Pliocene, but is slenderer and has fewer and more rounded ribs. Named for the type locality, Waldorf asphalt mine.

TYPE.—Cat. No. 165,270, U. S. N. M.

LOCALITY.—Waldorf asphalt mine, 3 miles southeast of Guadalupe, Santa Barbara County, California; locality No. 4473.

HORIZON.—Fernando formation, lower Pliocene portion.

BATHYTOMA CARPENTERIANA Gabb, var. FERNANDOANA, new variety

Pl. LVI, fig. 7

DESCRIPTION.—Shell averaging about 25 millimeters in altitude, broadly spindle-shaped; apex in type is imperfect, but from other specimens is known to be subacute. Whorls 4 or 5, more or less angulated, concave in front and convex behind, the anterior margin of each whorl appressed against the lower convex portion of the preceding one; body whorl similar to others except that it is protracted anteriorly, sculpture consisting of moderately sharp raised spiral lines, the penultimate whorl in the type carrying 9, 5 anterior to the angle and 4 posterior, the latter being slightly less prominent than those in front; the raised lines become more prominent on the anterior portion of the body, where they are wider spaced and the alternate ones are relatively more important; faint lines of growth, convex posteriorly on the angle and concave posteriorly on the posterior portion of the whorl, record a very wide, shallow notch as having been present in the lip. Suture slightly undulating, often prominent, owing to appressed portion of whorl being elevated slightly into a faint ridge just anterior to suture. Aperture narrow pyriform; canal very short and broad and only very slightly curved. Inner lip straight and smooth except for a single faint spiral ridge.

Dimensions.—Altitude, 24 mm.; latitude, 12.3 mm.; altitude of body whorl, 20 mm.; longitude of aperture and canal combined, 16 mm.; latitude of aperture, 5 mm.

Notes.—This variety is closely allied to the typical *B. carpenteriana,* but in the series of specimens examined is constantly smaller, relatively much shorter, and has the whorls more angulated than in the typical form. Named for the Fernando formation, of which it appears to be characteristic.

Type.—Cat. No. 165,303, U. S. N. M.

Locality.—Graciosa Ridge, near Folsom well No. 5, Orcutt, Santa Barbara County, California; locality No. 4476.

Horizon.—Fernando formation, Pliocene portion.

CANCELLARIA CRAWFORDIANA Dall, var. FUGLERI, new variety

Pl. LIV, fig. 9

Description.—Shell averaging between 20 and 25 millimeters in altitude, quite narrowly oval in outline. Spire elevated, and usually consisting of 5 or 6 whorls in addition to the body whorl. Whorls evenly convex and prominently angulated above, the portion of the whorl posterior to the angle forming a narrow revolving table. The surface of the whorls is cancellate, the sculpture consisting of narrow, rounded, raised revolving ridges (9 on the penultimate whorl, 18 on the body whorl in the type) and longitudinal ribs of the same character (23 on the penultimate whorl of the type) and prominence as the revolving ridges. Suture deeply appressed and distinct. Aperture ovate, canaliculated in front (the canal is broken off in the type). Columella with two prominent oblique plications.

Dimensions.—Altitude of imperfect specimen (type), 22 mm.;

latitude, 11.5 mm.; longitude of aperture without canal, 10 mm.; latitude of aperture, 5 mm.

NOTES.—This variety differs from the recent typical form in that the former has an average of many more (23 instead of 15) longitudinal ribs, more (9 instead of 7) spiral ridges, and a relatively narrower revolving table above the angle.

TYPE.—Cat. No. 165,322, U. S. N. M.

LOCALITY.—Fugler Point asphalt mine, 1 mile north of Gary, Santa Barbara County, California (U. S. G. S. locality No. 4475).

HORIZON.—Fernando formation (lower Pliocene).

NASSA WALDORFENSIS, new species

Pl. LIV, fig. 17

DESCRIPTION.—Shell averaging about 13 to 15 millimeters in altitude, sharply conical in outline, apex subacute. Whorls 6, convex, angulated near posterior margin. Suture appressed, distinct, wavy, sculpture consisting of sharp axial ribs (13 on penultimate whorl), extending with almost equal prominence from suture to suture, and prominent squarish revolving ridges (5 on penultimate whorl) separated by channeled interspaces, the whole presenting a most characteristic cancellate appearance; fine lines of growth are visible under a lens. Columella short, twisted and slightly curved; separated from body whorl by a distinct canal; sculptured much less prominently than whorls and by spiral lines only. Aperture broadly elliptical; canal short and sharply recurved; inner lip incrusted; outer lip slightly dentate.

DIMENSIONS.—Altitude, 13 mm.; latitude, 6.5 mm.; altitude of body whorl, 8 mm.; longitude of aperture, 4.8 mm.; latitude of aperture, 2.8 mm.; canal, 1.2 mm.

NOTES.—This species is slenderer and has coarser axial sculpture than *N. perpinguis* Hinds, and is somewhat smaller, relatively broader, and has much sharper ribs than *N. mendica* Gould; it is more closely related to the latter than to any other of the West Coast species. Found abundantly in the Pliocene throughout southern California. Named for the type locality, Waldorf asphalt mine.

TYPE.—Cat. No. 165,272, U. S. N. M.

LOCALITY.—Waldorf asphalt mine, 3 miles southeast of Guadalupe, Santa Barbara County, California; locality No. 4473.

HORIZON.—Fernando formation, lower Pliocene portion.

OCINEBRA MICHELI Ford, var. WALDORFENSIS, new variety

Pl. LIV, fig. 10

DESCRIPTION.—Shell averaging about 11 or 12 millimeters in altitude, rather slender, spindle-shaped; apex acute. Whorls 5, prominently angulated in the middle; anterior portion convex, posterior flat or concave, with a slight curving back of the posterior margin where it appresses against the preceding whorl. Sculpture consists of axial varices and spiral lines; axial varices (8 on penultimate whorl) are broad and rounded anterior to angle, narrower and sharper behind; the spiral lines are prominent only below the angle of each whorl; they are equal, rounded, ornamented by imbricating plates of growth, and are separated by distinct impressed interspaces; anterior portion of whorl sculptured by fine lines of growth. Suture appressed and not very distinct. Columella rather long, narrow, and recurved; spirally ribbed like body whorl. Aperture broadly pyriform; canal long, narrow, and recurved.

DIMENSIONS.—Altitude, 11 mm.; latitude, 5 mm.; altitude of body whorl, 8.4 mm.; longiture of aperture, 3.4 mm.; latitude of aperture, 1.3 mm.; canal, 3 mm.

NOTES.—This slender little *Ocinebra* differs from the typical *O. micheli* in the following respects: It is slenderer, has less angular whorls, and the imbricate sculpture on the posterior portion of the whorl is less prominently developed; the axial ribs are more prominent posterior to the angle, the spiral lines are equal, not alternate, the aperture is narrower, and the canal more recurved. Named for the type locality, Waldorf asphalt mine.

TYPE.—Cat. No. 165,261.

LOCALITY.—Waldorf asphalt mine, 3 miles southeast of Guadalupe, Santa Barbara, California; locality No. 4473.

HORIZON.—Fernando formation, lower Pliocene portion.

LEDA ORCUTTI, new species

Pl. LV, fig. 9

DESCRIPTION.—Shell averaging about 7 millimeters in longitude, solid, equivalve; beaks slightly anterior; anterior end rounded, shorter; posterior end rostrate, subacute; base arcuate; lunule long and very narrow, separated from shell by deeply impressed line; escutcheon much broader than lunule, its surface prominently concave and its carina well developed, especially toward the posterior end, sculpture consisting of several (7 in type) prominent wide spaced, narrow concentric riblets, this sculpture confined to the main portion of shell; lunule, escutcheon, and carinæ ornamented only by fine concentric incremental lines; incremental lines also visible between the concentric riblets. Hinge and interior similar in a general way to *L. minuta* Fabr.

DIMENSIONS.—Longitude, 7 mm.; altitude, 4.2 mm.; diameter, 3 mm.

NOTES.—This beautiful little *Leda* is allied to *L. minuta* Fabr., but differs from it in being less attenuate posteriorly, having coarser and wider spaced concentric riblets, and in having simple rather than biangular carinæ. A rather abundant species in the finer fossiliferous sands and shales of the lower Pliocene. Named in honor of Mr. W. W. Orcutt, of Los Angeles, California.

TYPE.—Cat. No. 165,271, U. S. N. M.

LOCALITY.—Waldorf asphalt mine, 3 miles southeast of Guadalupe, Santa Barbara County, California; locality No. 4473.

HORIZON.—Fernando formation, lower Pliocene portion.

PHACOIDES NUTTALLII Conrad, var. ANTECEDENS, new variety

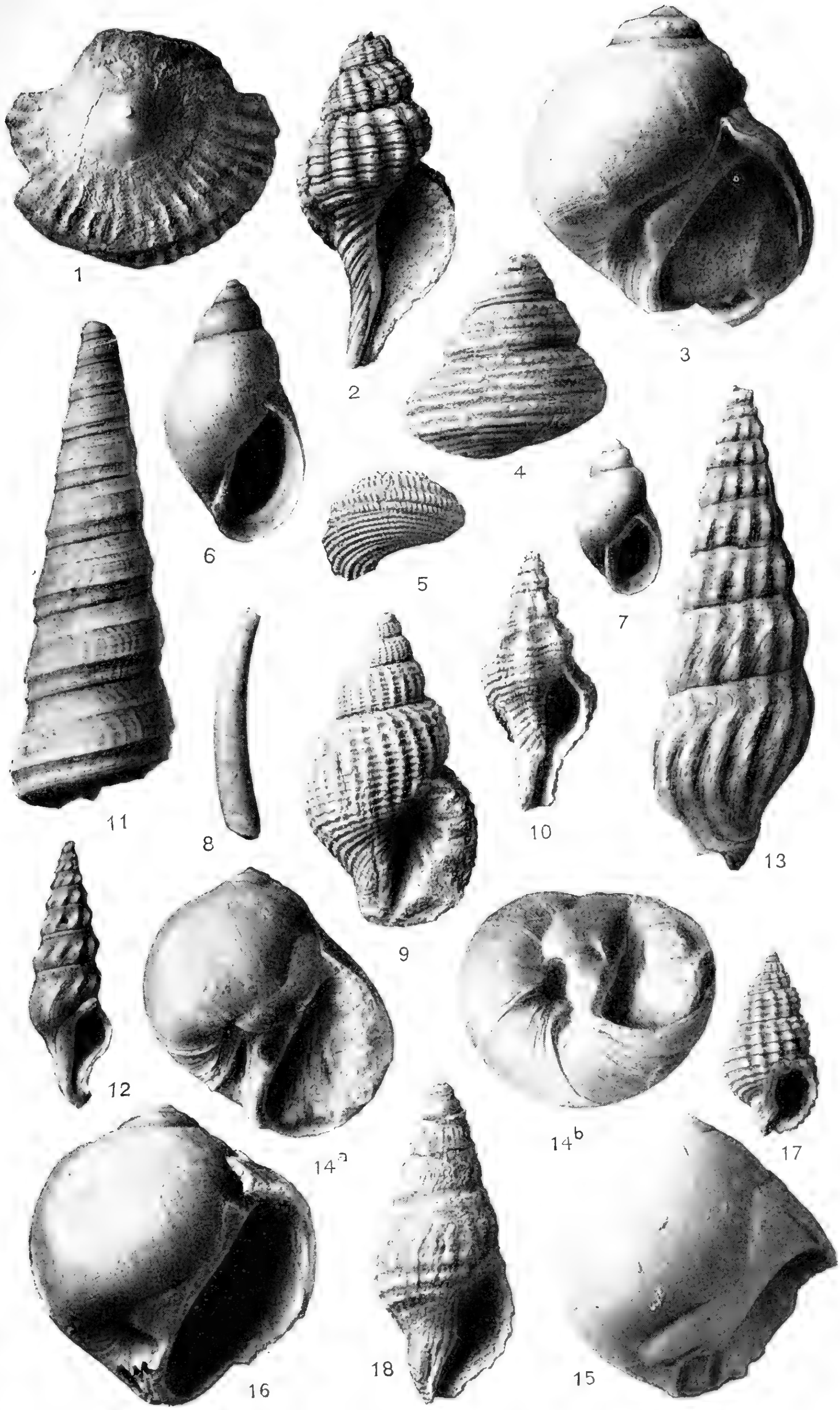
Pl. LV, fig. 6

DESCRIPTION.—Shell averaging about 25 millimeters in longitude, very broadly elliptical in outline, longer than high, ventricose, and equivalve; beaks only moderately prominent, placed slightly anterior to middle of shell; base arcuate; anterior margin sloping more rapidly from beaks than posterior, the latter being nearly straight for about 6 or 8 millimeters from the beaks; both extremities quite regularly rounded, the posterior being possibly slightly more attenuate, sculpture consisting of numerous close-set subequal rounded radiating ridges and concentric ribs which are narrower than the radials, and spaced about twice the distance between two of the latter; the concentric ribs tend to become obsolete toward the periphery in adult specimens; the general appearance of the surface is decidedly cancellate. Lunule deep, small, and inconspicuous. Interior and hinge as in *P. nuttallii.*

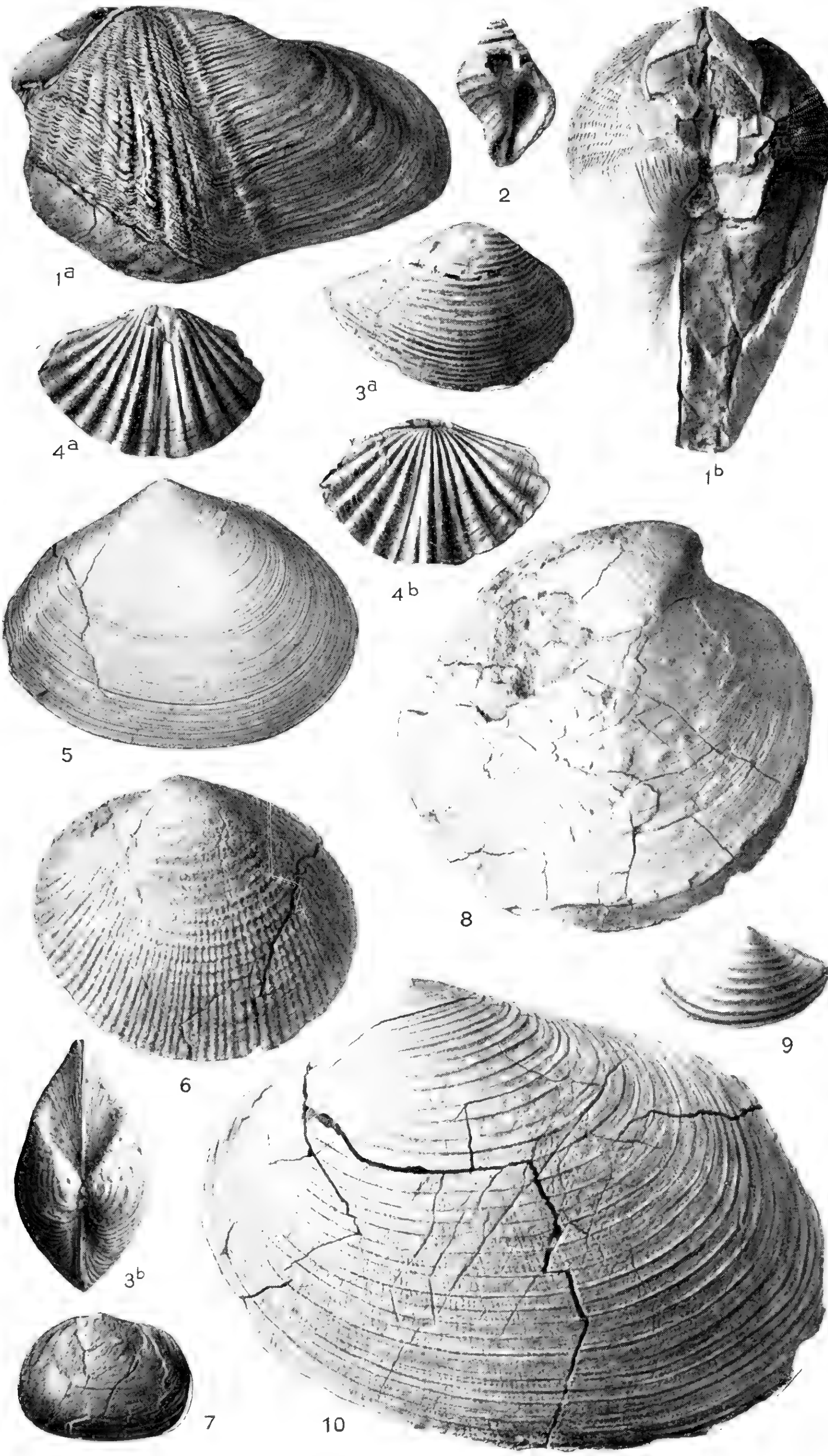
DIMENSIONS.—Longitude, 23 mm.; altitude, 19 mm.; diameter, 12 mm.

NOTES.—This variety is more ventricose, less angulated posteriorly, and has its concentric ribs much wider spaced than the typical *P. nuttallii.*

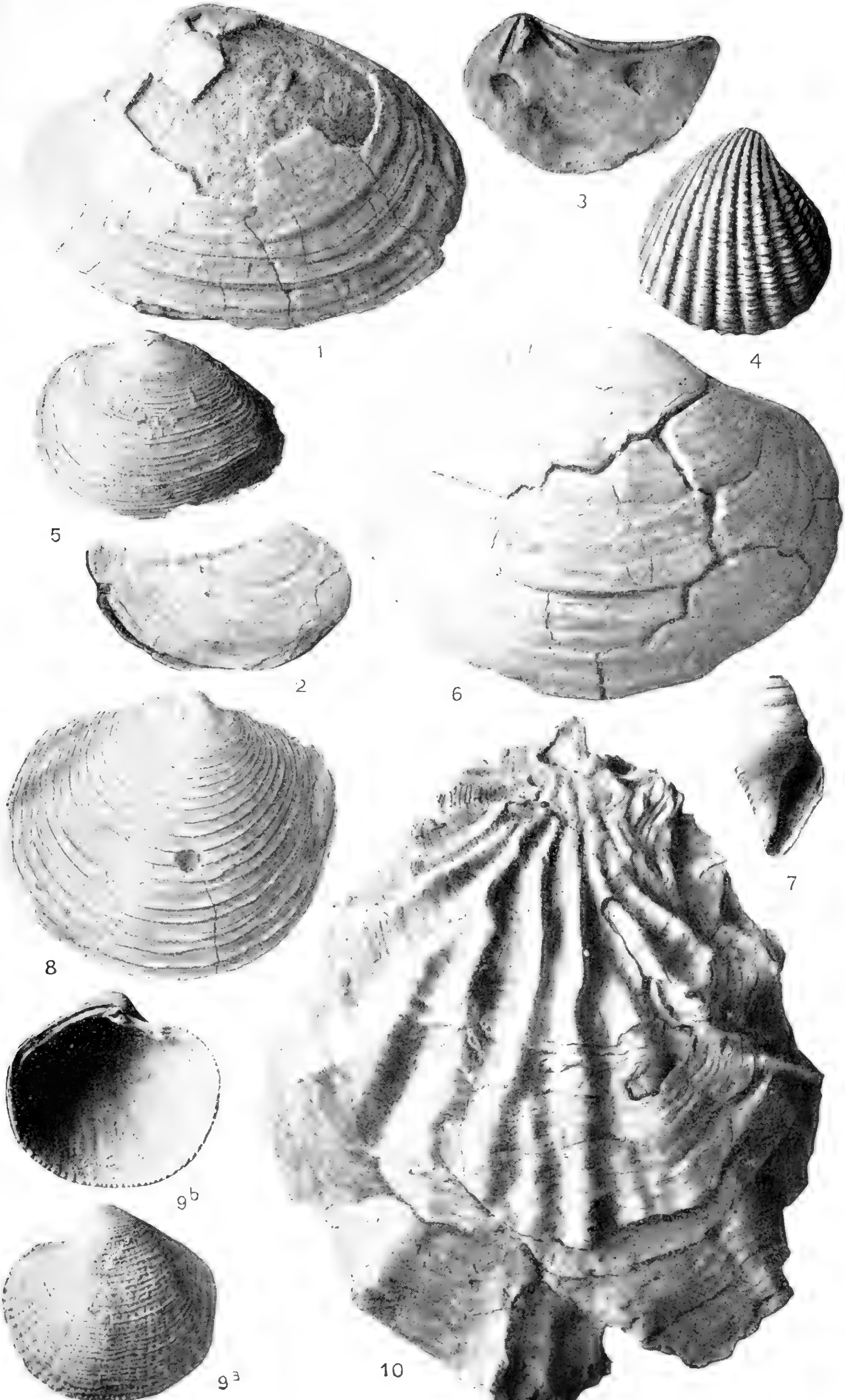
TYPE.—Cat. No. 165,290, U. S. N. M.



FERNANDO (PLIOCENE) GASTEROPODA



FERNANDO (PLIOCENE) FOSSILS



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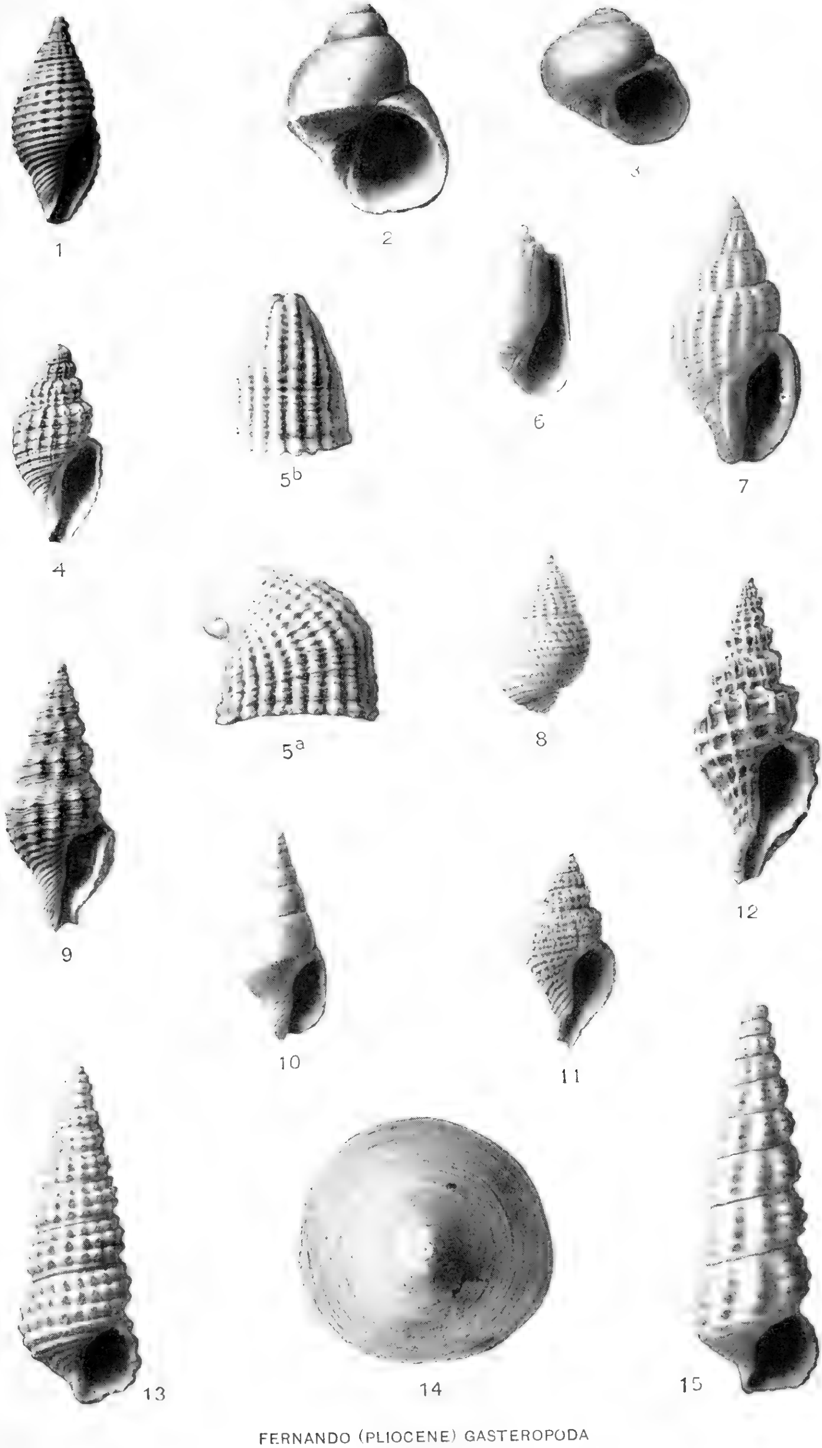
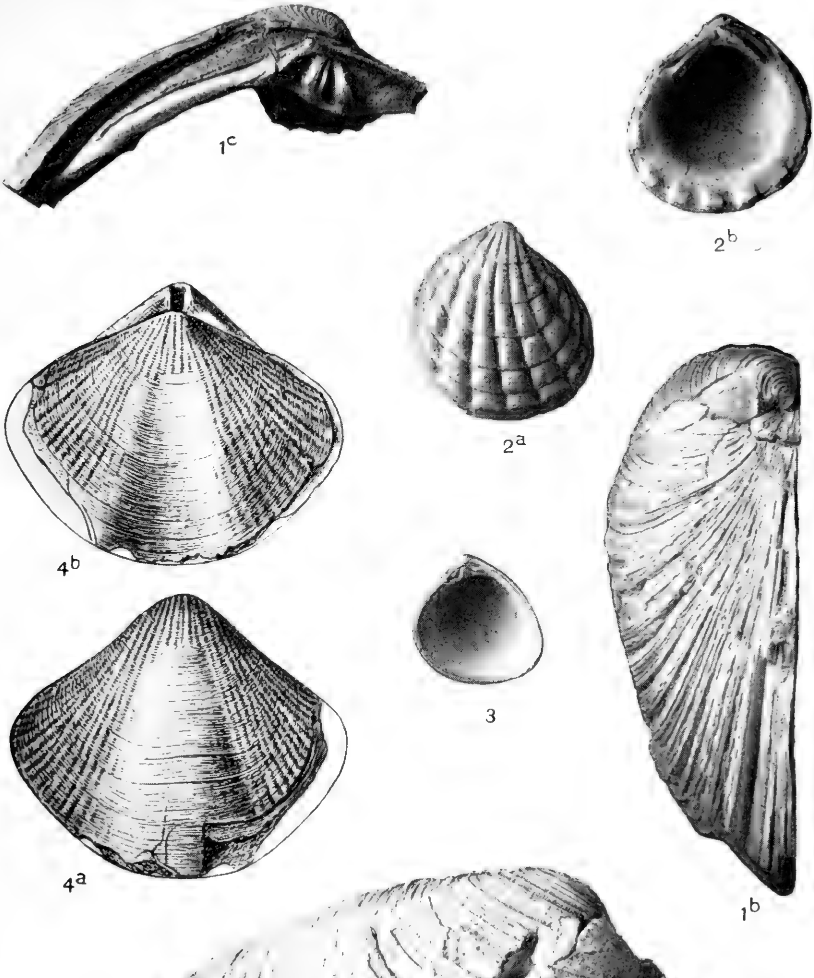


FERNANDO (PLIOCENE) GASTEROPODA



FERNANDO (PLIOCENE) PELECYPODA AND BRACHIOPODA

LOCALITY.—Alcatraz asphalt mine, near Sisquoc, Santa Barbara County, California; locality No. 4471.

HORIZON.—Fernando formation, lower Pliocene portion.

SPISULA CATILLIFORMIS Conrad, var. ALCATRAZENSIS, new variety

Pl. LVI, fig. 6

DESCRIPTION.—Shell averaging about 130 millimeters in longitude, oval in outline, slightly narrower in front than behind, equivalve, inequilateral, ventricose, extremities slightly gaping; base regularly arcuate; posterior portion of dorsal margin nearly straight at umbo, gradually becoming more and more arcuate as it passes around the broadly rounded extremity; anterior dorsal margin only slightly depressed in front of umbo, but carrying a slight bump only a short distance from the latter; anterior extremity more truncate and narrower than posterior; beaks slightly anterior, bent forward, but not exceptionally prominent. Surface consists of numerous more or less irregular lines of growth. Hinge and interior quite similar to typical form.

DIMENSIONS.—Longitude, 128 mm.; altitude, 98 mm.; diameter, 57 mm.

NOTES.—This variety is more ventricose, more excavated and attenuate in front, more regularly rounded below, and has the beaks more central than the typical *S. catilliformis*. Named for type locality, Alcatraz asphalt mine.

TYPE.—Cat. No. 165,291, U. S. N. M.

LOCALITY.—Alcatraz asphalt mine, near Sisquoc, Santa Barbara County, California; locality No. 4471.

HORIZON.—Fernando formation, lower Pliocene portion.

SPISULA SISQUOCENSIS, new species

Pl. LVI, fig. 1

DESCRIPTION.—Shell averaging about 120 millimeters in longitude, subtrigonal in outline, equivalve, inequilateral, ventricose; base regularly arcuate; beaks anterior, prominent, bent forward, protruding beyond periphery or shell; anterior end shorter and narrower than posterior, which is evenly rounded; area in front of beaks depressed concavely as a whole, but slightly elevated at margin, this condition, when the two valves are together, suggesting a large lunule with a slightly raised ridge running down the middle; posterior margin becomes more and more arcuate as extremity is approached, sculpture consisting of numerous fine incremental lines, some of which are more prominent than the great majority, these more prominent ones giving a slightly irregular surface to the shell. Hinge and interior unknown, but probably quite similar to *S. hemphilli.*

DIMENSIONS.—Longitude, 120 mm.; altitude, 85 mm.; diameter, 59 mm.

NOTES.—This species is near *S. hemphilli* Dall, but is constantly and decidedly narrower. Named for Sisquoc, near the type locality.

TYPE.—Cat. No. 165,292, U. S. N. M.

LOCALITY.—Alcatraz asphalt mine, near Sisquoc, Santa Barbara County, California; locality No. 4471.

HORIZON.—Fernando formation, lower Pliocene portion.

MITRAMORPHA FILOSA Carpenter, var. BARBARENSIS, new variety

Pl. LVII, fig. 1

DESCRIPTION.—Shell averaging between 6 and 7 millimeters in length, mitraform; apex quite acute. Whorls six, slightly ventricose, angulated above at suture; two nuclear whorls, smooth and somewhat irregular, the second being eccentric with relation to the axis of the spire; other whorls ornamented by four rounded, raised, revolving ridges and (16 on the penultimate whorl of the type) rounded longitudinal ribs. The longitudinal sculpture is relatively of greater prominence on the upper whorls and fades away below the middle of the body whorl. In the type the body whorl is sculptured by 16 revolving lines, those toward the base being faint. Suture appressed, distinct. Aperture narrow and elliptical; canal short. Outer lip smooth, inner lip slightly reflexed toward base, columella showing faint indications of two plications, lower part of columella showing trace of axial sculpture.

DIMENSIONS.—Altitude, 6.5 mm.; latitude, 2.6 mm.; altitude of aperture and canal, together, 3 mm.; latitude of aperture, 1 mm.

NOTES.—In this variety the whorls are more convex, the longitudinal sculpture much more pronounced, the suture more distinct, and the canal relatively narrower than in the type. It lies between *M. filosa* and *M. intermedia* Arnold, having more numerous and less prominent longitudinal ribs than the latter. Recent specimens of a variety of *M. filosa* very closely resembling var. *barbarensis* are in the National Museum labeled from Monterey. It is the opinion of the writer that the prominently longitudinally sculptured forms are northern types inhabiting somewhat colder water than the typical *filosa.*

TYPE.—Cat. No. 165,245, U. S. N. M.

LOCALITY.—Bath-house Beach, Santa Barbara, California. (Delos and Ralph Arnold.)

HORIZON.—Fernando formation (Pliocene or lower Pleistocene).

PUNCTURELLA DELOSI, new species

Pl. LVII, fig. 5*a* and 5*b*

DESCRIPTION.—Shell minute for one of this genus; body of shell roughly cylindrical, the cross-section of base being broadly elliptical, tapering off above into a coiled apex, the coil being right-handed and of about 1½ turns; a narrow slit about 0.7 mm. long perforates the shell in front of the apex and truncates one of the radiating ribs. The axis of the slit is parallel with the longer axis of the elliptical base. The sculpture consists of (in the type 23) prominent equal, equidistant, rounded, raised ridges, which radiate from the apex toward the periphery or base; near the apex these ridges are quite sharp. The interspaces are slightly narrower than the ribs and are crossed by numerous sharp raised lamellæ of growth which flex forward and give the surface a cancellated appearance. These lamellæ also cross the radiating ribs, giving them an imbricated or nodose surface. The lamellæ are more numerous on the anterior or cylindrical part of the shell. The interior of the shell is smooth. A raised border or septum associated internally with the slit divides the shell near the apex, crossing parallel with the narrow axis of the base.

DIMENSIONS.—Altitude, 1.8 mm.; longer diameter of base, 1.8 mm.; shorter diameter, 1.6 mm.

NOTES.—This species of *Puncturella* is very much smaller than any other from the West Coast. Its shape is also quite distinctive and its ribs equal in size rather than alternating or subequal, as in the previously described forms. Two specimens only were found at the type locality. Named in honor of Delos Arnold, of Pasadena, California.

TYPE.—Cat. No. 165,234, U. S. N. M.

LOCALITY.—Bath-house Beach, Santa Barbara, California. (Delos Arnold.)

HORIZON.—Fernando formation (Pliocene or lower Pleistocene).

VENERICARDIA YATESI, new species

Pl. LVIII, figs. 2*a* and 2*b*

DESCRIPTION.—Shell averaging between 4 and 5 millimeters in altitude, subcircular in outline, moderately convex. Beaks slightly posterior, turned slightly forward, and somewhat prominent. Anterior margin slightly depressed in front of beaks, but convex below this; anterior angle somewhat more sharply rounded than posterior, giving the valve an obliquely protruding appearance anteriorly. Posterior margin and base regularly rounded. The sculpture consists of 8 or 9 broad falcate ribs separated by narrow incised interspaces and several (8 in the type) very prominent concentric imbrications of growth; in addition to the latter are numerous fine incremental lines. Hinge relatively narrow for one of this genus.

DIMENSIONS.—Altitude, 4 mm.; latitude, 4 mm.; diameter of single valve, 1 mm.

NOTES.—This species is more closely related to *V. incisa* Dall than to any of the other West Coast forms, but is easily distinguishable from the latter by the fewer number (8 in type of *yatesi,* 19 in type of *incisa*) and greater breadth of its ribs, relatively smaller size and shorter and more angulated outline anteriorly. Named in honor of Dr. Lorenzo G. Yates, Santa Barbara, California.

TYPE.—Cat. No. 165,248, U. S. N. M.

LOCALITY.—Bath-house Beach, Santa Barbara, California. (Delos and Ralph Arnold.)

HORIZON.—Fernando formation (Pliocene or lower Pleistocene).

PSEPHIDIA BARBARENSIS, new species

Pl. LVIII, fig. 3

DESCRIPTION.—Shell averaging about 4 millimeters in altitude; subtrigonal in outline, ventricose. Beaks slightly anterior of the center, bowed slightly forward, but not prominent. Anterior margin nearly straight; anterior angle broadly rounded; base not prominently rounded; posterior angle much sharper than anterior; posterior margin regularly bowed and much more rounded than anterior. Surface smooth except for very fine lines of growth. Muscle scars prominent; pallial sinus oblique and extending nearly to middle of valve. The hinge consists of three prominent teeth—the middle one heavy, triangular, and slightly sulcated, the anterior and posterior ones short.

DIMENSIONS.—Altitude, 4 mm.; longitude, 4.1 mm.; diameter of single valve, 1 mm.

NOTES.—This species is higher and more trigonal in outline, has a straighter anterior margin, and a less conspicuous anterior tooth than *P. lordii* Baird, which it resembles. Named for the type locality, Santa Barbara.

TYPE.—Cat. No. 165,238, U. S. N. M.

LOCALITY.—Bath-house Beach, Santa Barbara, California. (Delos and Ralph Arnold.)

HORIZON.—Fernando formation (Pliocene or lower Pleistocene).

EXPLANATION OF PLATES

All figures are natural size unless otherwise indicated. Unless otherwise indicated, all specimens figured are from Santa Barbara County, California.

PLATE L

Tejon (Eocene) Fossils

FIG. 1. *Cardium brewerii* Gabb. Type. View of exterior of right valve; altitude, 61 mm. Pal. Cal. I, pl. XXIV, fig. 155. A common species in the Eocene of the Santa Ynez Mountains.

2*a*. *Crassatellites collina* Conrad. Cat. No. 165,312, U. S. N. M. View of exterior of left valve; longitude, 87 mm. San Julian ranch; locality No. 4507. A characteristic species of the Tejon in the Santa Ynez Range.

2*b*. View of anterior end of same specimen.

3. *Crassatellites collina* Conrad. Cat. No. 165,312, U. S. N. M. View of hinge. Same locality as fig. 2*a*.

4. *Pecten* (*Chlamys* ?) *yneziana*, new species. Cat. No. 165,313, U. S. N. M. Paratype. View of exterior; altitude, 52 mm. San Julian ranch; locality No. 4507. A characteristic species of the Tejon in the Santa Ynez Range.

5*a*. *Ficus mamillatus* Gabb. Cat. No. 165,319, U. S. N. M. View of back; altitude, 31 mm.; 3 miles north of Sudden; locality No. 4518. Quite rare, but nevertheless found at most Tejon localities in the southern Coast Ranges.

5*b*. View of same specimen from above.

6. *Turritella uvasana* Conrad. Cat. No. 165,327, U. S. N. M. Aperture view of imperfect specimen; altitude, 25 mm.; 3 miles north of Sudden; locality No. 4518. Characteristic of the Tejon on the West Coast.

PLATE LI

Knoxville (Cretaceous) and Tejon (Eocene) Fossils

FIG. 1. *Aucella piochii* Gabb. Cat. No. 30,831, U. S. N. M. View of exterior of right valve; altitude, 25 mm. Knoxville (Lower Cretaceous) formation, East Fork Tepusquet Creek; locality No. 4173. Characteristic of the Knoxville throughout the Coast Ranges.

2. *Aucella piochii* Gabb. Cat. No. 30,831, U. S. N. M. View of exterior of left valve, × 2. Same locality and horizon as fig. 1.

3*a*. *Aucella piochii* Gabb. View of exterior of left valve; altitude, 27 mm. Bull. U. S. Geol. Survey, No. 133, 1895, pl. IV, fig. 6.

3*b*. Exterior of right valve of same specimen. *Op. cit.*, pl. IV, fig. 7.

4. *Venericardia planicosta* Lamarck. Cat. No. 164,973, U. S. N. M. Exterior view of left valve; longitude, 84 mm. Eocene, Little Falls, Washington. This is the most widespread and characteristic Eocene species in the world.

5*a*. *Turritella* (*martinezensis* Gabb, var. ?) *lompocensis*, new variety. Cat. No. 165,316, U. S. N. M. Paratype. Back view of basal fragment; altitude, 30 mm. Southwest of Lompoc, in San Miguelite Canyon; locality No. 4509.

5*b*. Basal view of same specimen.

6*a*. *Pecten* (*Chlamys* ?) *yneziana*, new species. Cat. No. 165,313. Type. View of exterior of imperfect disk; altitude, 64 mm. San Julian ranch, 10 miles southeast of Lompoc; locality No. 4507.

6*b*. View of hinge of right valve of same species; length, 25 mm.

7. *Turritella uvasana* Conrad. Cat. No. 165,326, U. S. N. M. Aperture view of imperfect specimen; altitude, 68 mm. San Julian ranch, southeast of Lompoc; locality No. 4507. Characteristic of the Tejon of the Pacific Coast.

8. *Turritella* (*martinezensis* Gabb, var. ?) *lompocensis*, new variety. Cat. No. 165,316, U. S. N. M. Type. View of back; altitude, 68 mm. Same locality as fig. 5*a*.

Plate LII

Vaqueros (Lower Miocene) Fossils

Fig. 1*a*. *Purpura vaquerosensis*, new species. Collection of Delos Arnold. Type. Aperture view; altitude, 100 mm. Lynch Mountain, Monterey County.

1*b*. Back view of same specimen.

2. *Modiolus ynezianus*, new species. Cat. No. 165,324, U. S. N. M. Type. View of exterior of right valve, × 2. San Julian ranch, southeast of Lompoc; locality No. 4504.

Plate LIII

Vaqueros (Lower Miocene) Fossils

Fig. 1. *Pecten* (*Pecten*) *vanvlecki*, new species. Cat. No. 165,305, U. S. N. M. Type. View of exterior of right valve; altitude, 64 mm. Mouth of Ballard Canyon, 2 miles south of Santa Ynez; locality No. 4478.

2. *Pecten* (*Pecten*) *vanvlecki*, new species. Cat. No. 165,306, U. S. N. M. Paratype. View of exterior of left valve; altitude, 72 mm. Same locality as fig. 1.

3. *Pecten* (*Chlamys*) *sespeensis*, var. *hydei* Arnold. Cat. No. 165,308, U. S. N. M. View of exterior of left valve; altitude, 60 mm. Mouth of Ballard Canyon, south of Santa Ynez; locality No. 4478. This species is apparently characteristic of the Vaqueros.

4*a*. *Terebratalia kennedyi* Dall. Cat. No. 165,325, U. S. N. M. View of exterior of ventral valve; altitude, 26 mm. Lime quarry 5 miles southwest of Lompoc; locality No. 4521. The specimens from this quarry are indistinguishable from the type of *T. kennedyi*, which came from Cerros Island, Lower California.

4*b*. View of exterior of imperfect dorsal valve of same species; altitude, 18 mm.

4*c*. View of exterior of dorsal valve of same species; altitude, 19 mm.

4*d*. View of exterior of ventral valve of same species; altitude, 28 mm.

PLATE LIV

Fernando (Pliocene) Gasteropoda

FIG. 1. *Trochita radians* Lamarck. Cat. No. 165,310, U. S. N. M. View of top of imperfect specimen; maximum diameter, 20 mm., × 2. Fugler Point asphalt mine, near Gary; locality No. 4475. Characteristic of the upper Miocene and lower Pliocene in this region.

2. *Priene oregonensis* Redfield. Cat. No. 165,262, U. S. N. M. Aperture view of young specimen; altitude, 46 mm. Waldorf asphalt mine; locality No. 4473. This species is also found recent.

3. *Lunatia lewisii* Gould. Cat. No. 165,264, U. S. N. M. Aperture view of young specimen; altitude, 23 mm., × 2. Waldorf asphalt mine; locality No. 4473; also known recent.

4. *Thalotia caffea* Gabb. Cat. No. 165,298, U. S. N. M. Back view; latitude, 29 mm. Fugler Point asphalt mine, near Gary; locality No. 4475; also known recent.

5. *Thalotia caffea* Gabb. Cat. No. 165,297, U. S. N. M. View of side of fragment, slightly tilted up; latitude, 21 mm.; same locality as fig. 4.

6. *Lymnæa alamosensis,* new species. Cat. No. 165,426, U. S. N. M. Type. Aperture view; altitude, 6 mm., × 6. Fresh-water beds 1 mile southeast of bench-mark 425, Los Alamos Valley; locality No. 4483.

7. *Lymnæa alamosensis,* new species. Cat. No. 165,426, U. S. N. M. Aperture view of young specimen; altitude, 3.5 mm., × 6. Same locality as fig. 6.

8. *Cadulus fusiformis* Sharp and Pilsbry. Cat. No. 165,267, U. S. N. M. Side view; longitude, 10 mm., × 3. Waldorf asphalt mine; locality No. 4473; also known recent.

9. *Cancellaria crawfordiana* Dall, var. *fugleri,* new variety. Cat. No. 165,322, U. S. N. M. Type. Aperture view; altitude, 22.5 mm., × 2. Fugler Point asphalt mine, near Gary; locality No. 4475.

10. *Ocinebra micheli* Ford, var. *waldorfensis,* new variety. Cat. No. 165,261, U. S. N. M. Type. Altitude, 11 mm.; aperture view, × 3. Waldorf asphalt mine; locality No. 4473.

11. *Turritella cooperi* Carpenter. Cat. No. 165,273, U. S. N. M. Altitude, 34 mm.; aperture view, × 2. Waldorf asphalt mine; locality No. 4473. Common in the Pliocene and Pleistocene.

12. *Drillia waldorfensis,* new species. Cat. No. 165,270, U. S. N. M. Type. Aperture view of imperfect specimen; altitude, 18.5 mm., × 2. Waldorf asphalt mine; locality No. 4473.

13. *Drillia johnsoni* Arnold. Cat. No. 165,263, U. S. N. M. Altitude, 34 mm.; back view, × 2. Waldorf asphalt mine; locality No. 4473; also found fossil at San Pedro.

14*a*. *Neverita recluziana* Petit. Cat. No. 165,323, U. S. N. M. Altitude, 35 mm.; aperture view. Fugler Point asphalt mine, near Gary; locality No. 4475; also known recent.

14*b*. View of base of same specimen.

15. *Neverita recluziana* Petit. Cat. No. 165,299, U. S. N. M. Altitude, 20 mm.; aperture view, × 2. Fugler Point asphalt mine, near Gary; locality No. 4475.

16. *Natica clausa* Broderip and Sowerby. Cat. No. 165,269, U. S. N. M. Altitude, 21 mm.; aperture view, × 2. Waldorf asphalt mine; locality No. 4473; also known recent.

17. *Nassa waldorfensis,* new species. Cat. No. 165,272, U. S. N. M. Type. Altitude, 13 mm.; aperture view, × 2. Waldorf asphalt mine; locality No. 4473.

18. *Drillia graciosana,* new species. Cat. No. 165,309, U. S. N. M. Type. Altitude, 14 mm.; aperture view, × 2. Graciosa Ridge, near Orcutt; locality No. 4476.

PLATE LV

Fernando (Pliocene) Fossils

FIG. 1*a*. *Pholadidea ovoidea* Gould. Cat. No. 165,277, U. S. N. M. Longitude, 58 mm.; view of valve. Waldorf asphalt mine; locality No. 4473; also known recent.

1*b*. View of both valves of same specimen from above.

2. *Purpura crispata* Chemnitz. Cat. No. 165,278, U. S. N. M. Altitude, 20 mm.; aperture view. One mile north of Schumann; locality No. 4474; also known recent.

3*a*. *Leda taphia* Dall. Cat. No. 165,296, U. S. N. M. View of exterior of valve; longitude, 10.5 mm., × 3. Fugler Point asphalt mine, near Gary; locality No. 4475; also known recent.

3*b*. View of both valves of same specimen from above.

4*a*. *Terebratalia occidentalis* Dall. Cat. No. 165,300, U. S. N. M. View of exterior of ventral valve; latitude, 30 mm. Fugler Point asphalt mine, near Gary; locality No. 4475. A variable species extending from the upper Miocene to Recent faunas.

4*b*. View of dorsal valve of same specimen.

5. *Macoma nasuta* Conrad. Cat. No. 165,276, U. S. N. M. Longitude, 47 mm.; view of right valve. Waldorf asphalt mine; locality No. 4473. Extends from the Miocene to the Recent fauna.

6. *Phacoides nuttallii* Conrad, var. *antecedens,* new variety. Cat. No. 165,290, U. S. N. M. Type. View of exterior of left valve; longitude, 23 mm., × 2. Alcatraz asphalt mine, near Sisquoc; locality No. 4471.

7. *Cryptomya ovalis* Conrad. Cat. No. 165,289, U. S. N. M. Left valve; longitude, 23 mm. Alcatraz asphalt mine, near Sisquoc; locality No. 4471. Apparently characteristic of the lower Pliocene.

8. *Dosinia ponderosa* Gray. Cat. No. 165,295, U. S. N. M. View of exterior of right valve; altitude, 105 mm., × ½. Alcatraz asphalt mine, near Sisquoc; locality No. 4471; also known recent farther south.

9. *Leda orcutti,* new species. Cat. No. 165,271, U. S. N. M. Type. View of exterior; longitude, 7 mm., × 3. Waldorf asphalt mine; locality No. 4473.

10. *Tapes tenerrima* Carpenter. Cat. No. 165,293, U. S. N. M. View of exterior of left valve; longitude, 83 mm. Alcatraz asphalt mine, near Sisquoc; locality No. 4471. Common in the Pliocene; also known recent farther north.

Plate LVI

Fernando (Pliocene) Fossils

Fig. 1. *Spisula sisquocensis,* new species. Cat. No. 165,292, U. S. N. M. Type. View of exterior of left valve; longitude, 120 mm., × ½. Alcatraz asphalt mine, near Sisquoc; locality No. 4471.

2. *Clidiophora punctata* Carpenter. Cat. No. 165,302, U. S. N. M. View of exterior of right valve; longitude, 36 mm. Graciosa Ridge, near Orcutt; locality No. 4476; also known recent.

3. *Clidiophora punctata* Carpenter. Cat. No. 165,283, U. S. N. M. View of interior of left valve; longitude, 35 mm. Graciosa Ridge, near Orcutt; locality No. 4476.

4. *Venericardia californica* Dall. Cat. No. 165,274, U. S. N. M. Altitude, 29 mm.; aperture view. Waldorf asphalt mine; locality No. 4473. A magnificent species common in and characteristic of the lower Pliocene.

5. *Cumingia californica* Conrad. Cat. No. 165,311, U. S. N. M. View of exterior of left valve; longitude, 17 mm., × 2. Fugler Point asphalt mine, near Gary; locality No. 4475; also known recent.

6. *Spisula callilliformis* Conrad, var. *alcatrazensis,* new variety. Cat. No. 165,291, U. S. N. M. Type. View of exterior of right valve; longitude, 128 mm., × ½. Alcatraz asphalt mine, near Sisquoc; locality No. 4471.

7. *Bathytoma carpenteriana* Gabb, var. *fernandoana,* new variety. Cat. No. 165,303, U. S. N. M. Type. Altitude, 24 mm.; aperture view. Graciosa Ridge, near Orcutt; locality No. 4476.

8. *Phacoides annulatus* Reeve. Cat. No. 165,286, U. S. N. M. View of exterior of right valve; longitude, 45 mm. One mile north of Schumann; locality No. 4474. Common in the Fernando, and also found recent in southern waters.

9*a*. *Phacoides intensus* Dall. Cat. No. 165,260, U. S. N. M. View of exterior of left valve; altitude, 6.5 mm., × 4. Waldorf asphalt mine; locality No. 4473. Found in lower Pliocene as far south as San Diego.

9*b*. View of interior of same specimen, × 4.

10. *Ostrea veatchii* Gabb. Cat. No. 165,282, U. S. N. M. View of exterior of left valve; altitude, 96 mm. One mile north of Schumann; locality No. 4474. Found in same horizon as far south as San Diego.

PLATE LVII

Fernando (Pliocene) Gasteropoda

(All specimens are from Fernando formation, Bath-house Beach, Santa Barbara.)

FIG. 1. *Mitramorpha filosa* Carpenter, var. *barbarensis,* new variety. Cat. No. 165,245, U. S. N. M. Type. Altitude, 6.5 mm.; aperture view, × 4. Characteristic of this horizon.

2. *Lacuna compacta* Carpenter. Cat. No. 165,235, U. S. N. M. Altitude, 6.5 mm.; aperture view, × 4; also known recent.

3. *Leptothyra bacula* Carpenter. Cat. No. 165,236, U. S. N. M. Diameter, 3 mm.; aperture view, × 6; also known recent.

4. *Mangilia tabulata* Carpenter. Cat. No. 165,240, U. S. N. M. Altitude, 4 mm.; aperture view, × 4; also known recent.

5*a*. *Puncturella delosi,* new species. Cat. No. 165,234, U. S. N. M. Type. Altitude, 1.9 mm.; view of side, × 10. Characteristic of this horizon.

5*b*. Rear view of same specimen, × 10.

6 *Tornatina culcitella* Gould. Cat. No. 165,239, U. S. N. M. Altitude, 5 mm.; aperture view, × 4; also known recent.

7. *Amphissa corrugata* Reeve. Cat. No. 165,243, U. S. N. M. Altitude, 11 mm.; aperture view, × 3; also known recent.

8. *Nassa perpinguis* Hinds. Cat. No. 165,237, U. S. N. M. Altitude, 10 mm.; aperture view, × 2; also known recent.

9. *Clathurella conradiana* Gabb. Cat. No. 165,247, U. S. N. M. Altitude, 11 mm.; aperture view, × 3; also reported as recent, but the recent form is probably another species or variety.

10. *Columbella* (*Astyris*) *tuberosa* Carpenter. Cat. No. 165,242, U. S. N. M. Altitude, 9 mm.; aperture view, × 3; also known recent.

11. *Ocinebra lurida* Middendorf. Cat. No. 165,233, U. S. N. M. Altitude, 12 mm.; aperture view, × 2; also known recent.

12. *Trophon* (*Boreotrophon*) *stuarti* Smith. Cat. No. 165,244, U. S. N. M. Altitude, 20 mm.; aperture view, × 2; also known recent.

13. *Bittium catalinensis* Bartsch. Cat. No. 165,232, U. S. N. M. Type. Altitude, 7 mm.; aperture view, × 6.

14. *Galerus mammillaris* Broderip. Cat. No. 165,251, U. S. N. M. Maximum diameter, 17 mm.; view of top, × 2; also known recent.

15. *Bittium barbarensis* Bartsch. Cat. No. 165,231, U. S. N. M. Type. Altitude, 8.5 mm.; aperture view, × 6.

PLATE LVIII

Fernando (Pliocene) Pelecypoda and Brachiopoda

(Unless otherwise stated, all specimens are from Fernando formation, Bath-house Beach, Santa Barbara.)

FIG. 1*a*. *Mercenaria perlaminosa* Conrad. Cat. No. 165,252, U. S. N. M. Right valve; longitude, 87 mm.; view of exterior. Characteristic of this horizon.

1*b*. View of the same specimen from front.

1c. *Mercenaria perlaminosa* Gabb. Cat. No. 165,288, U. S. N. M. Longitude of fragment, showing hinge of left valve, 56 mm. Characteristic of this horizon.

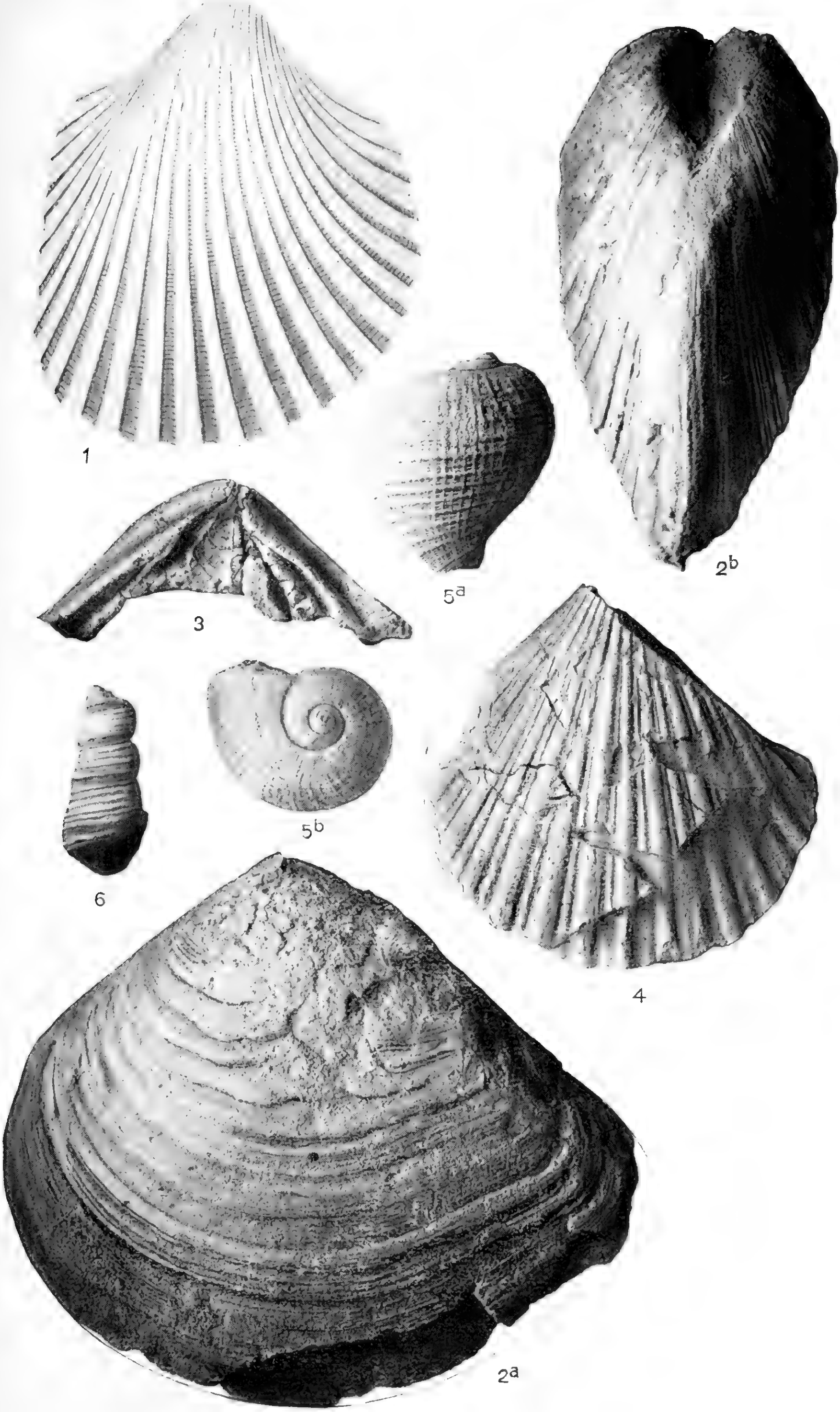
2a. *Venericardia yatesi,* new species. Cat. No. 165,248, U. S. N. M. Type. Right valve; latitude, 4 mm.; view of exterior, × 6. Characteristic of this horizon.

2b. View of interior of same specimen.

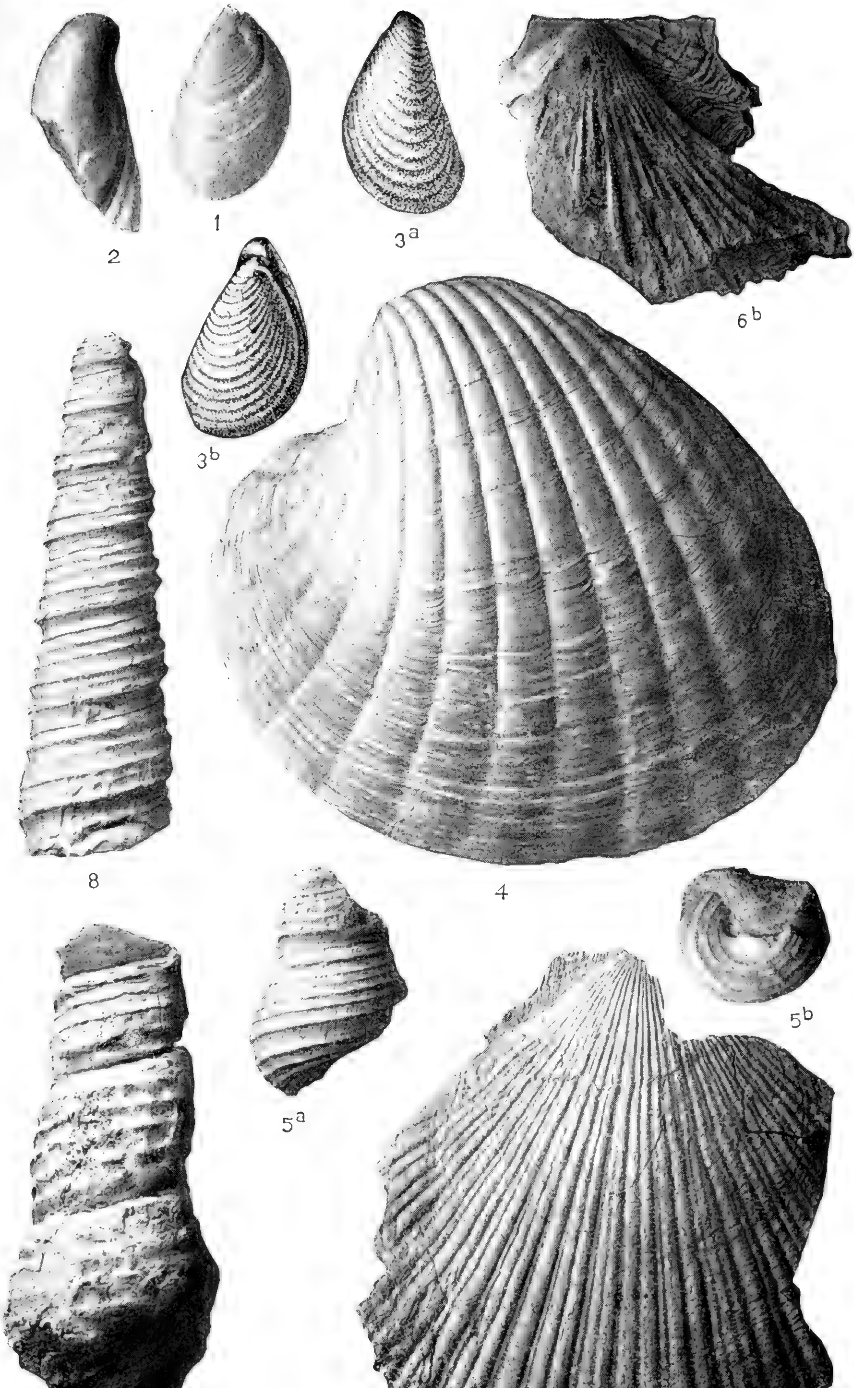
3. *Psephidia barbarensis,* new species. Cat. No. 165,238, U. S. N. M. Type. Altitude, 4 mm.; view of interior, × 4. Characteristic of this horizon.

4a. *Terebratalia hemphilli* Dall. Cat. No. 108,495, U. S. N. M. Holotype. Proc. U. S. Nat. Mus., XXIV, 1902, pl. XL, fig. 10. Ventral valve; longitude, 35 mm.; view of exterior, slightly enlarged. Arroyo Burro, west of Santa Barbara.

4b. Exterior of view of dorsal valve of same specimen. *Op. cit.,* pl. XL, fig. 8.

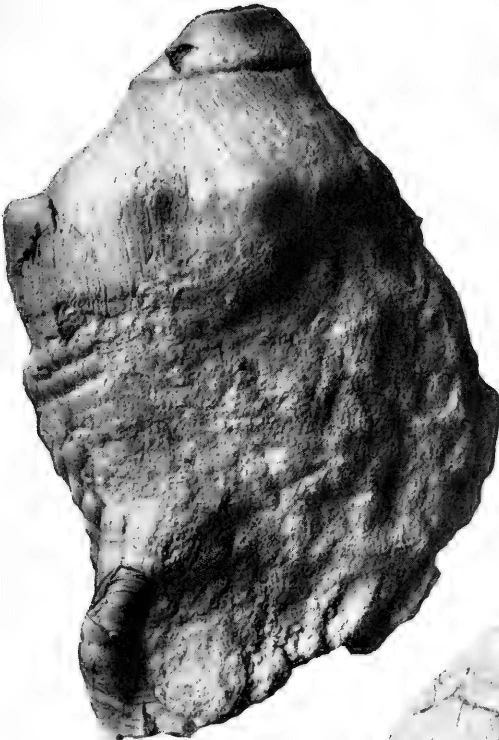


TEJON (EOCENE) FOSSILS



KNOXVILLE (CRETACEOUS) AND TEJON (EOCENE) FOSSILS

2



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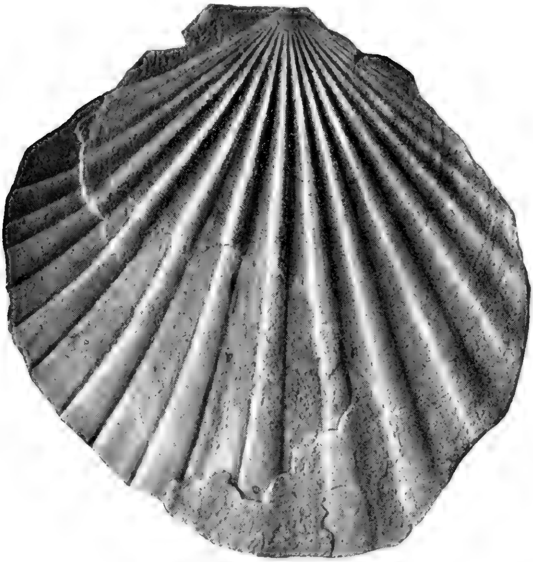
VAQUEROS (LOWER MIOCENE) FOSSILS



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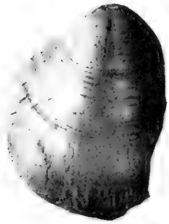

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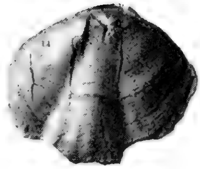

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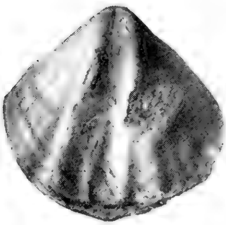

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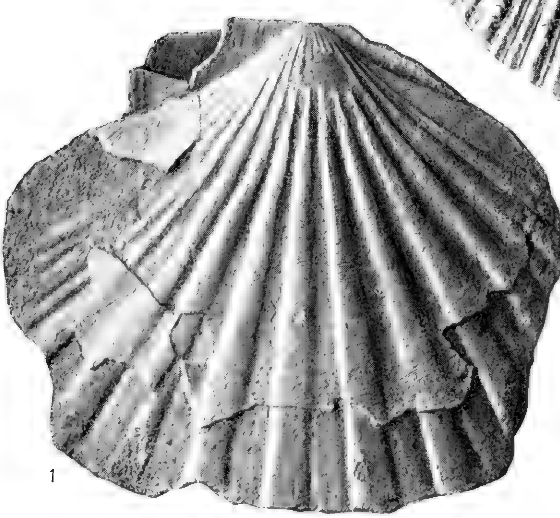

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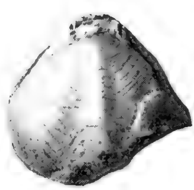

4ᵇ

VAQUEROS (LOWER MIOCENE) FOSSILS

ON THE OCCURRENCE OF REMAINS OF FOSSIL CETACEANS OF THE GENUS *SCHIZODELPHIS* IN THE UNITED STATES, AND ON *PRISCODELPHINUS* (?) *CRASSANGULUM* CASE

By FREDERICK W. TRUE

Head Curator of Biology, U. S. National Museum

(With two plates)

In 1904 Mr. E. C. Case described in the Report of the Maryland Geological Survey[1] a skull of a fossil porpoise, which he assigned provisionally to the genus *Priscodelphinus*, as a new species, under the name of *Priscodelphinus* (?) *crassangulum*. The type specimen was obtained on the shore of Chesapeake Bay, three-fourths of a mile north of Governor's Run, Calvert County, Maryland, from the Miocene marl belonging to the Calvert formation. The type consists of the rostrum of the skull, nearly complete, a part of the basis of the skull, one zygomatic process, one occipital condyle, a tympanic bulla, and the mandible, which is nearly complete, but lacks the condyles. In addition, a large fragment, which resembles the orbital process of the frontal, is present; but, as will be explained later, I have been unable to satisfy myself that it is really such. Among other fragments, which I have been unable to identify positively, are some which appear to represent the thin portions of the pterygoids. No teeth were preserved. The rostrum, mandible, *basis cranii*, zygomatic process, occipital condyle, and tympanic bulla were figured by Mr. Case.[2]

While studying the types of various fossil cetaceans in the collections of Johns Hopkins University and of the Maryland Geological Survey, I was permitted by Prof. William B. Clark to bring the type of Mr. Case's species to Washington, where it has been put together under my direction. As Mr. Case's figures are from drawings, I have thought it desirable to supplement them by figures reproduced from photographs.

Before considering this valuable specimen in detail, I desire to make certain observations regarding the genus *Priscodelphinus*. The genus was established by Leidy in 1851 or 1852[3] on the basis of a dorsal

[1]Report of Maryland Geological Survey, Miocene, text, 1904, p. 12, pl. 11, figs. 1-3.

[2] *Op. cit.*, pl. 11, figs. 1–3.

[3] Proc. Acad. Nat. Sci. Phila., 5, p. 326. Read Dec. 9, 1851.

vertebra from the green sand of Mullica Hills, New Jersey, which had been mentioned and figured by Harlan in 1824 as that of a saurian.[1] Leidy dedicated the species to Harlan, under the name of *Priscodelphinus harlani*.

I examined the type specimen of this species in Philadelphia in the spring of the present year, and compared it with Harlan's figure, which is a very good representation of it. The epiphyses, which are anchylosed to the centrum, are thin. There is a distinct keel, the outline of which is concave when viewed from the side. The transverse processes are recurved at the end and thickened, and have a rounded ridge superiorly near the posterior margin. The articular surface for the rib is oval in outline. The superior surface of the centrum is very concave, with a narrow median ridge reaching nearly to the epiphyses at both ends.

Cope in 1868[2] remarked that there were a few more vertebræ of this species in the collection of the Philadelphia Academy, but I did not find them. In 1890 Cope united *P. harlani* with *P. grandævus* Leidy,[3] but, as Leidy had pointed out previously, the latter appears to be a considerably larger species. However this may be, Leidy himself placed *grandævus* in the genus *Priscodelphinus,* and the species was described at the same time with *harlani*. Various other species based on vertebræ were assigned to *Priscodelphinus* by Leidy and Cope from time to time. The characters of a genus, however, are not properly elucidated by such material.

Cope's diagnosis of *Priscodelphinus,* published in 1868,[4] relates entirely to the vertebræ, but in referring to it in the previous year (1867) he remarked: "In this genus the muzzle is elongate and flattened, and furnished with cylindrical fanged teeth, which extend throughout much or all of its length. The symphysis mandibuli is very elongate. The teeth have not been described. *Delphinus canaliculatus* von Meyer (Palæontographica, 1856, p. 44), from the Swiss Tertiary, appears to belong to it."[5] In 1890[6] he stated that *P. grandævus* had "a slender muzzle, with a full series of curved cylindric teeth; a neck like that of a seal in proportions, and a long slender body. The first sternal segment is T-shaped, and the ribs are slender, compressed, and mostly two-headed." His diagnosis of the genus, published at the same time, comprises the following char-

[1] Journ. Acad. Nat. Sci. Phila., 4, 1824, p. 232, pl. 14, fig. 1.
[2] Proc. Acad. Nat. Sci. Phila., 1868, p. 159.
[3] Amer. Nat., 1890, p. 615.
[4] Proc. Acad. Nat. Sci. Phila., 1868, pp. 186, 187.
[5] *Loc. cit.*, 1867, p. 145.
[6] Amer. Nat., 1890, p. 604.

acters: "Teeth with cylindric roots, caudal vertebræ plane; lumbar diapophyses wide, flat; muzzle elongate, slender; cervical vertebræ long." In connection with this diagnosis, Cope published figures of seven cervical vertebræ, the manubrium of a sternum, and a rib, from Cumberland County, New Jersey, which he assigned to *P. grandævus*. The type of the species was from this county, but it is not clear on what ground Cope associated the specimens above mentioned with the type, except that they were from the same locality, or how he ascertained that the muzzle was elongated in the genus *Priscodelphinus*. Probably the latter assertion was based on the fact that Leidy, in 1869, mentioned a portion of an elongated rostrum in the Philadelphia Academy as probably representing *P. grandævus*.[1] According to Leidy, it came from the same locality as the type vertebræ, at a later date, and accompanied another lot of vertebræ. He remarked, "It is suspected to belong to the same animal."

The fact that this rostrum came from the same locality as the type vertebræ of a species of *Priscodelphinus* is an insufficient reason for placing it in the same genus. It is well known that the remains of many genera and several families of Cetacea are found in the marine Miocene formations of the east coast of the United States. Until a skull (or at least part of one) is found with some vertebræ which can be identified with the type vertebræ of *Priscodelphinus harlani* or *grandævus,* under such circumstances that their connection cannot be doubted, the real characters of *Priscodelphinus* can hardly be determined. A comparison of vertebræ which have been assigned to different species of *Priscodelphinus* with one another, and with those of European genera supposed to be closely allied, will doubtless throw some light on the subject. So far as present evidence goes, there is some ground for believing that vertebræ like those of *P. harlani* can properly be associated with *Schizodelphis,* or, in other words, that the genus *Priscodelphinus* will eventually prove identical with *Schizodelphis.*

In the meantime, I agree with Mr. Case that his species *crassangulum* is only doubtfully to be associated generically with such species as *Priscodelphinus harlani, grandævus,* etc. On the other hand, there appears to be good reason for placing it in the genus *Schizodelphis* Gervais (= *Cyrtodelphis* Abel).[2] Dr. Abel's recharacterization of this genus, under the name of *Cyrtodelphis* Abel, is as follows:

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[1] Journ. Acad. Nat. Sci. Phila., (2), 7, 1869, p. 434. This rostrum was figured by Case in Report of Maryland Geological Survey, Miocene, pl. 15, fig. 1, but the scale should be $\frac{1}{2.5}$ instead of $\frac{1}{3}$.

[2] See C. R. Eastman, Bull. Mus. Comp. Zool., 51, 1907, p. 84.

Symphysis long, occupying about two-thirds the length of the jaw. Outer side of lower jaw with long vascular impressions, which often unite to form a groove, which is broad and shallow at first and afterward narrow and deep. Angle of the symphysis rounded. The lower borders of the rami concave, the upper bent inward, so that, seen from above, the rami, with the angle of the symphysis, assume an elongated oval form. Alveoli numerous, reaching up on the rami. Teeth small; those on the rami short cone-shaped, with the crown bent backward and swollen above the base.

Premaxillæ approximated, anchylosed together in age, depressed in the nasal region, with many grooves in the broader part which converge anteriorly. Nasals small. Interparietal enclosed between the two frontals and the occipital. Frontals mostly free, covered by the maxillæ only on the sides.[1]

The skull of *crassangulum* presents the majority of these characters, and especially those of the lower jaw, on the conformation of which, according to Dr. Abel, the chief reliance is to be placed. As nearly all of the brain-case and adjoining parts are lacking, the agreement, as regards the form of the frontals, nasals, etc., cannot be determined.

Schizodelphis sulcatus is peculiar as regards the form of the brain-case. The supraoccipital is very low and the frontals occupy a very large area on the vertex. As a result, the cranium is depressed and somewhat rectangular, and the temporal fossæ are irregularly pentangular. The palate is deeply grooved and its surface more or less rounded. The teeth are comparatively few in number and widely spaced, but the two rows are closely approximated anteriorly, at least in the mandible.

In the shape of the palate, the greater number of teeth, and the greater relative distances between the rows, *Schizodelphis crassangulum* differs from *sulcatus*. It seems best at present, however, to regard these differences as specific rather than generic.

Mr. Case has described the type specimen of *crassangulum* quite in detail. The following notes relate chiefly to characters which are not mentioned by him, or to such as seem to me worthy of a more extended description:

At the middle point of the rostrum a cross-section of the premaxillæ forms nearly the quadrant of a circle, the height and breadth being about equal. As they extend forward they become gradually more depressed, while posteriorly they become higher, until they reach a point about opposite the posterior end of the tooth-row, beyond which they become rapidly lower again and also broader. This broad portion is nearly flat. It is succeeded further back by a second broad, flattened area, which is separated from the first by a distinct

[1] Denkschr. k. Akad. Wiss. Wien, Math.-Nat.-Wiss. Classe, 68, 1900, p. 849.

groove. This groove runs diagonally toward the median line, and thence anteriorly along the inner margin of each premaxilla to a point a little in advance of the line of the posterior end of the tooth-row. The posterior ends of the premaxillæ are lacking.

The maxillæ at the middle of the rostum are much narrower than the premaxillæ (viewed from above, only about half as broad). They taper gradually anteriorly, as do the premaxillæ. Posteriorly they increase in breadth gradually, and opposite the posterior end of the tooth-row appear to have been originally about as broad as the premaxillæ at the same point. They increase in breadth rapidly posterior to this point, with nearly straight free margins and the upper surface nearly plane, but inclined inward.

On the upper surface of the rostrum the suture between the maxillæ and premaxillæ is in a groove, which is traceable throughout the length of the rostrum and appears to have been especially deep at the base of the latter.

The inferior or palatal surface of the rostrum is flat, and is bisected by a longitudinal triangular median groove, 3 mm. wide and 2 mm. deep at the middle point. This groove is bounded on each side by the sharp inner edge of the inferior palatal surface of the maxilla, which does not curve upward to meet it, as in *S. sulcatus*. It increases greatly in breadth and decreases in depth anteriorly, and at the end of the rostrum fades away altogether, leaving the whole palatal surface flat.

At the anterior end of the rostrum the premaxillæ occupy more than half the palatal surface and form a triangular area between the maxillæ. This triangle is greatly prolonged posteriorly, and the thin strips of the premaxillæ probably extend in the median groove nearly as far back as the line of the posterior end of the tooth-row, where the vomer appears between the maxillæ, but the sutures are not distinct.

The vomer is visible as a linear slip for a distance of 77 mm. in front of the anterior insertion of the palatine bones, and probably extended 30 mm. further originally, or 107 mm. in all.

A triangular rugose area 55 mm. long at the base of the maxillæ indicates the position of the palatine bones, but the ridges probably do not represent any portion of the bones themselves. Farther back there is a shallow depression on the palatal surface of the maxillæ, laterally.

The thin inflated portion of the pterygoids is not developed, or may be represented by small pieces, which cannot be joined to the posterior thicker part. The latter, which borders the nares posteriorly, is concave externally and convex internally.

The alveoli are directed downward, forward, and outward. They are all somewhat flattened and elliptical in outline, but some of the posterior ones are more nearly circular. The bony septa between them are all incomplete in the specimen, but were probably complete originally and at least half as broad as the alveoli. On the right side, 65 alveoli can be counted, and as the rostrum is nearly complete, this was probably about the original number of teeth.

The nares are small and have a longitudinal diameter of 15 mm. The posterior vertical free border of the vomer is concave and ends abruptly on meeting the surface of the basisphenoid. The free margins of the inferior lateral borders of the basisphenoid are very rough. The basioccipital is lacking, except a small fragment attached to the occipital condyle. Only the left condyle is present. It is 45 mm. high and 30 mm. broad. It is closely appressed to the surface of the exoccipital, the outer margin being only 9 mm. at most from that surface.

Only the left zygomatic process of the temporal is present. It is 75 mm. long from its articulation with the exoccipital to the anterior free end and 51 mm. from the tip of the postglenoid process to the lower margin of the temporal fossa. Enough of the posterior margin of the temporal fossa remains to indicate that it was nearly semicircular, and that it extended backward little, if any, beyond the line of the occipital condyles. The glenoid surface of the zygomatic is 41 mm. broad and only slightly concave. The free margin is quite thin, both laterally and in front. The exoccipital terminates in a semicircular process, with the end truncated and deeply pitted.

The length of the symphysis of the mandible is 444 mm., and when complete was probably but little longer. At the middle of its length the breadth is 28 mm. On the line of the posterior end of the symphysis the breadth is 50 mm. and the depth 29 mm. The superior surface of the symphysis is flat, with a median groove, which is about 2 mm. broad at the middle point. It dies away gradually anteriorly and is bifurcated posteriorly. The tooth-row extends about 23 mm. beyond the posterior end of the symphysis. The internal surface of the anterior end of the rami is convex, the external surface nearly plane, and the inferior margin rounded. The rami diverge at an angle of about 45°. The apex of the angle is rounded.

The inferior surface of the symphysis is rounded and is divided on each side by a very distinct groove, which is deepest posteriorly, becomes shallower anteriorly, and disappears near the tip of the jaw, where the surface is nearly flat. The bottom of the groove is occupied by several foramina, which are prolonged into narrow channels running forward. At the widest point the main grooves have a breadth of 6 mm. The rounded eminence between them is 12 mm. broad at the middle of the symphysis.

The alveoli are like those of the upper jaw, being somewhat elliptical in outline, and are directed forward, outward, and upward. At the tip of the jaw the roots of the teeth, at least, must have been directed almost horizontally. A few of the posterior septa are complete and are nearly as broad as the diameter of the alveoli. More anteriorly they are less distinct and were probably incomplete. This is especially true at the tip of the jaw, where the alveoli are very close together. On the left side about 67 alveoli can be counted, which was probably nearly the full number of teeth. The dentition would then be about $\frac{65-65}{67-67} = 264$.

The posterior portion of one of the rami is present, but lacks the condyle. Mr. Case gives the length from the posterior end of the symphysis to the posterior end of the ramus as 199 mm., but when the fragment above mentioned is placed so as to be in contact with the portion of the ramus attached to the symphysis, this length is 232 mm. It is certain, however, that a portion of the ramus is lacking. When complete its length must have been considerably greater than is indicated by either of the foregoing measurements. The dental canal appears to have had a wide orifice, as in the Delphinidæ, *Mesoplodon*, etc., rather than as in *Platanista* and *Inia*.

The left tympanic bulla, which is the only one preserved, is 52 mm. long and 30 mm. broad. The inferior surface is divided unsymmetrically by a deep longitudinal furrow, the latter being nearest the inner lip. This groove continues to the posterior end of the bulla, where it lies between the two rounded prominences which represent the termination of the outer and inner lips. The inner prominence is only a little smaller than the outer one and is equally rounded. The inferior surface of the inner lip and of the bottom of the furrow is rugose; the surface of the outer lip is smooth. The anterior end of the bulla is acuminate. The lateral and superior surfaces of the inner lip are divided by a broad, shallow groove running transversely near the posterior end. A similar groove in the outer lip runs in front of the sigmoid process. The inner wall of the concavity of the bulla is rugose.

The frontals were briefly described by Mr. Case, and there is with the type specimen, as already mentioned, a piece about 85 mm. long and 58 mm. wide, which may represent the orbital part of one of these bones. After repeatedly examining it, however, I am unable to satisfy myself that it is really such. It has one thick edge, which may be the orbital free border, and an opposite thin edge. The superior surface (supposing it to be such) exhibits a shallow, semicircular depression, which might mark the position of the superimposed maxilla. With the bone thus oriented, however, the under surfaces are not readily interpreted, nor does the bone agree in general form with the frontal plate shown in any figure of *Schizodelphis*, *Champsodelphis*, or *Acrodelphis* which I have been able to find. In my opinion, the fragment represents a portion from the side of the basisphenoid of a species of *Mesoplodon*, and has, therefore, no connection with the type specimen of *S. crassangulum*.

In 1900 Dr. Abel united several European species formerly assigned to the genera *Champsodelphis*, *Schizodelphis*, *Platydelphis*, *Cetorhynchus*, etc., under his genus *Cyrtodelphis*, grouping them in two species—*C. sulcatus* and *C. christolii*.[1] Subsequently he withdrew *C. christolii* to another genus and family.[2] In 1907 Dr. C. R. Eastman pointed out that *Cyrtodelphis* was a synonym of *Schizodelphis*,[3] and Abel's remaining species therefore becomes *Schizodelphis sulcatus* (Gervais).

It is evident that *S. crassangulum* (Case) is not identical with *S. sulcatus*. The latter is considerably larger, with a more massive beak and fewer teeth, more widely spaced. The teeth are about $\frac{39}{39}$ to $\frac{49}{49}$ in *sulcatus*, while in *crassangulum* they are about $\frac{65}{67}$. In the former species 5 teeth are included in a length of 50 mm., as against 8 teeth in *S. crassangulum*.

The type specimen of *S. sulcatus* appears to be a skull from Vendargues, Department of Herault, France, which was first described by Gervais in 1840, under the name of *Delphinus pseudodelphis*.[4] The condition of this skull is such that it can scarcely be used in comparative studies. Having found that the specific name was preoccupied, he changed it in 1853 to *sulcatus*,[5] and at the same time described another skull, obtained from Couronsec (Herault), France. This specimen, which was in excellent condition, may be considered the real type of the species. As already stated, it is larger than that of *crassangulum*. The teeth are larger, fewer, and more widely spaced, the palate is deeply concave above the

[1] Denkschr. k. Akad. Wiss. Wien, Math.-Nat.-Wiss. Classe, 68, 1900, p. 850.

[2] Mém. Mus. Roy. Hist. Nat. Belg., 3, 1905, p. 95.

[3] Bull. Mus. Comp. Zool., 51, 1907, p. 84.

[4] Bull. Acad. Sci. Montpellier, 1840, p. 11.

[5] Bull. Soc. Geol. France, 10, 1853, p. 312.

median line instead of flat, as in *crassangulum,* and the two rows are closely approximated anteriorly. It does not seem to me quite certain that the species *canaliculatus* Meyer, *planus* Gervais, *depereti* Paquier, and *dationum* Gervais[1] are identical with *sulcatus,* as Dr. Abel believes. The mandible of *caniculatus* Meyer is of about the same size as that of *crassangulum,* or is even smaller. The mandibular alveoli are equal in size and also the septa between them. In *caniculatus,* however, the inferior mandibular channels appear to become deeper and narrower anteriorly, while in *crassangulum* they become much wider and shallower, and finally disappear altogether.

In the species *planus* Gervais the palate is flat, as in *crassangulum,* but about twice as wide, while the alveoli and septa are equal in size. The *depereti* of Paquier appears to resemble *sulcatus* closely, except in proportions. The anterior mandibular teeth are much larger than in *crassangulum* and are directed upward rather than outward. The portion of the symphysis between the two rows is much narrower.

As to *dationum* Gervais,[2] the angle of the mandibular symphysis is so small that the species should probably be assigned to *Acrodelphis* rather than to *Schizodelphis.* The jaw is of about the same size as that of *crassangulum,* but the teeth are larger and more widely spaced.

As already mentioned (p. 450), Cope, in 1867, when treating of the genus *Priscodelphinus,* remarked, "*Delphinus canaliculatus* von Meyer, from the Swiss Tertiary, appears to belong to it (Palæontographia, 1856, p. 44)". Von Meyer's species belongs to the genus *Schizodelphis,*[3] and Cope's statement amounts, therefore, to a provisional introduction of the genus *Schizodelphis* into the North America fossil fauna. Should his surmise be confirmed, the name *Priscodelphinus* (1852) would supplant *Schizodelphis* for both European and American species. It is not clear on what ground Cope based his opinion, as *S. canaliculatus* was described from mandibles, and no mandibles of *Priscodelphinus* were known. To a certain extent he was probably influenced by an examination of the beak from Cumberland County, New Jersey, which is mentioned by Leidy (see p. 451) as probably representing *Priscodelphinus grandævus.* This beak, which was figured by Mr. Case in 1904,[4] is still preserved in the Academy of Natural Sciences of Philadelphia. Its

[1] In part, Zool. et Pal. Franç., ed. 2, 1859, pl. 83, figs. 1, 2.

[2] *Op. cit.,* Ostéogr. des Cét., pl. 57, fig. 11.

[3] It is made a synonym of *S. sulcatus* (Gervais) by Dr. Abel, but may be a separate species.

[4] Report of Maryland Geological Survey, Miocene, pl. 15, fig. 1.

dimensions are as follows: Total length of the fragment, 325 mm.; breadth at posterior end, 49 mm.; breadth at anterior end, 33; breadth of the two premaxillæ at the posterior end, 26; the same at the anterior end, 24; breadth of palate at the middle of the length of the fragment, 39; breadth between alveoli (transverse) at the same point, 26; space between adjoining alveoli, 7; length of an anterior alveolus, 7.5; breadth of the same, 6; length of a posterior alveolus, 6; breadth of the same, 4; depth of the beak at the anterior end, 19; depth at the posterior end, 28.

The beak is broad and depressed, especially at the anterior end, where, however, it is not complete. The premaxillæ are high and rounded posteriorly, low and flattened anteriorly. Together they are nearly as wide anteriorly as posteriorly, and on account of their being depressed look wider. The maxillæ are triangular in section, with a rounded external free margin. The palate is flat, with a median wedge-shaped groove. The vomer is not visible on the palate. The alveoli are directed downward and forward. The anterior ones are larger than the posterior. In the fragment preserved there are 22 on the left side and 20 on the right side. The roots of the teeth are preserved in the 13th, 14th, and 17th alveoli of the right side. They appear somewhat oval in section and are directed backward, but are not flattened below.

Schizodelphis crassangulum appears to be a rather common species in the Miocene marls of Maryland. Among specimens from the Calvert Cliffs in the National Museum, collected by myself, are 7 more or less imperfect tympanic bullæ, which are identical with the bulla belonging to the type specimen; also fragments of premaxillæ and of the mandibular symphysis.

MEASUREMENTS OF THE TYPE SPECIMEN OF SCHIZODELPHIS CRASSANGULUM (CASE)

	Mm.
Total length of rostrum (as preserved)	595
Length from posterior end of superior tooth-row to anterior end of rostrum	433
From insertion of palatines to end of rostrum	498
Breadth of rostrum opposite the posterior end of the tooth-row	48
Depth at the same point	33
Breadth of rostrum midway between posterior end of tooth-row and tip	25
Depth at the same point	16
Breadth of premaxillæ at the same point	15
Height of premaxillæ at the same point	7
Breadth of premaxillæ at tip of rostrum	13
Greatest breadth of left premaxilla proximally	25
Breadth of mesethmoid at anterior end	18
Height of mesethmoid at anterior end	37
Least breadth between blowholes	11
Greatest breadth between free margins of basisphenoid	71
Length of zygomatic process from postglenoid process to anterior free end	76
Breadth of zygomatic process from outer margin of temporal fossa to glenoid process	51
Height of occipital condyle	46
Breadth of occipital condyle	29
Total length of mandible (as preserved)	590
Length from angle of symphysis to tip of mandible	446
Breadth of mandible opposite angle of symphysis	53
Depth of mandible opposite angle of symphysis	24
Breadth of mandible midway between angle of symphysis and tip	27
Depth at the same point	12
Breadth between inferior mandibular grooves at the same point	12
Breadth of mandible at distal end (about)	19
Depth of mandible at distal end	7
Distance between the two tooth-rows at the distal end	9
Length of tooth-row posterior to angle of symphysis	17
Greatest length of tympanic bulla	51
Greatest breadth of tympanic bulla	28
Length of orifice of tympanic bulla	41
Breadth of bulla at posterior end	24

EXPLANATION OF PLATES

PLATE LIX

FIG. 1. Type specimen of *Schizodelphis crassangulum* (Case), (=*Priscodelphinus* ? *crassangulum* Case). Superior surface of the rostrum. One-third natural size.

FIG. 2. The same. Superior surface of the mandible. One-third natural size.

FIG. 3. The same. Inferior surface of the rostrum. One-third natural size.

FIG. 4. The same. Inferior surface of the mandible. One-third natural size.

PLATE LX

FIG. 1. Type specimen of *Schizodelphis crassangulum*. Left side of rostrum and mandible. One-third natural size.

FIG. 2. The same. Left zygomatic process of the temporal, exoccipital, and occipital condyle. Posterior view. One-half natural size.

FIG. 3. The same specimen and parts. Anterior view. One-half natural size.

FIG. 4. The same specimen. Left tympanic bulla. Inferior surface. One-half natural size.

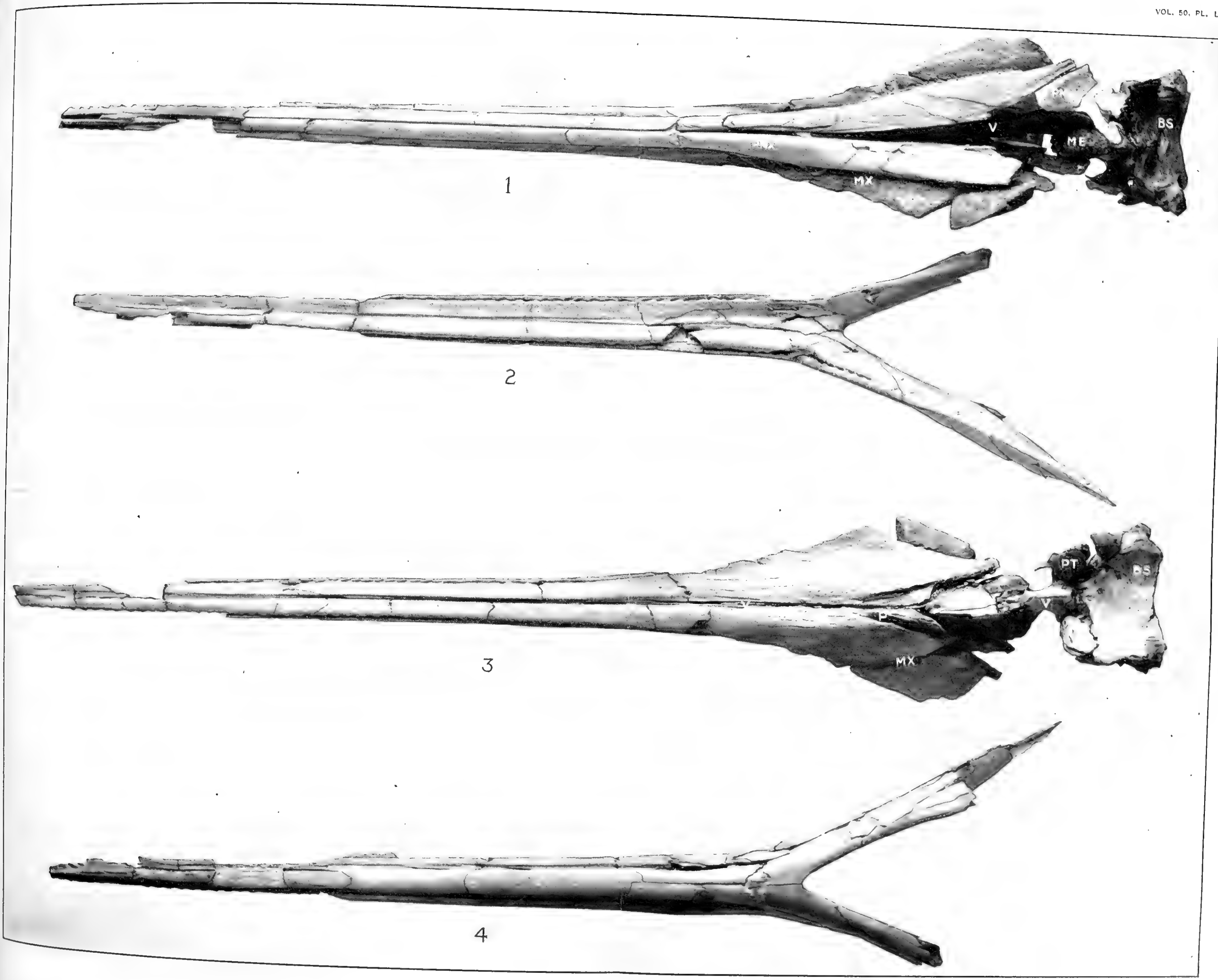
FIG. 5. The same. Internal surface. One-half natural size.

FIGS. 6–11. Fragments of tympanic bullæ of *S. crassangulum* from Chesapeake Beach, Md. (In the U. S. National Museum.) One-half natural size.

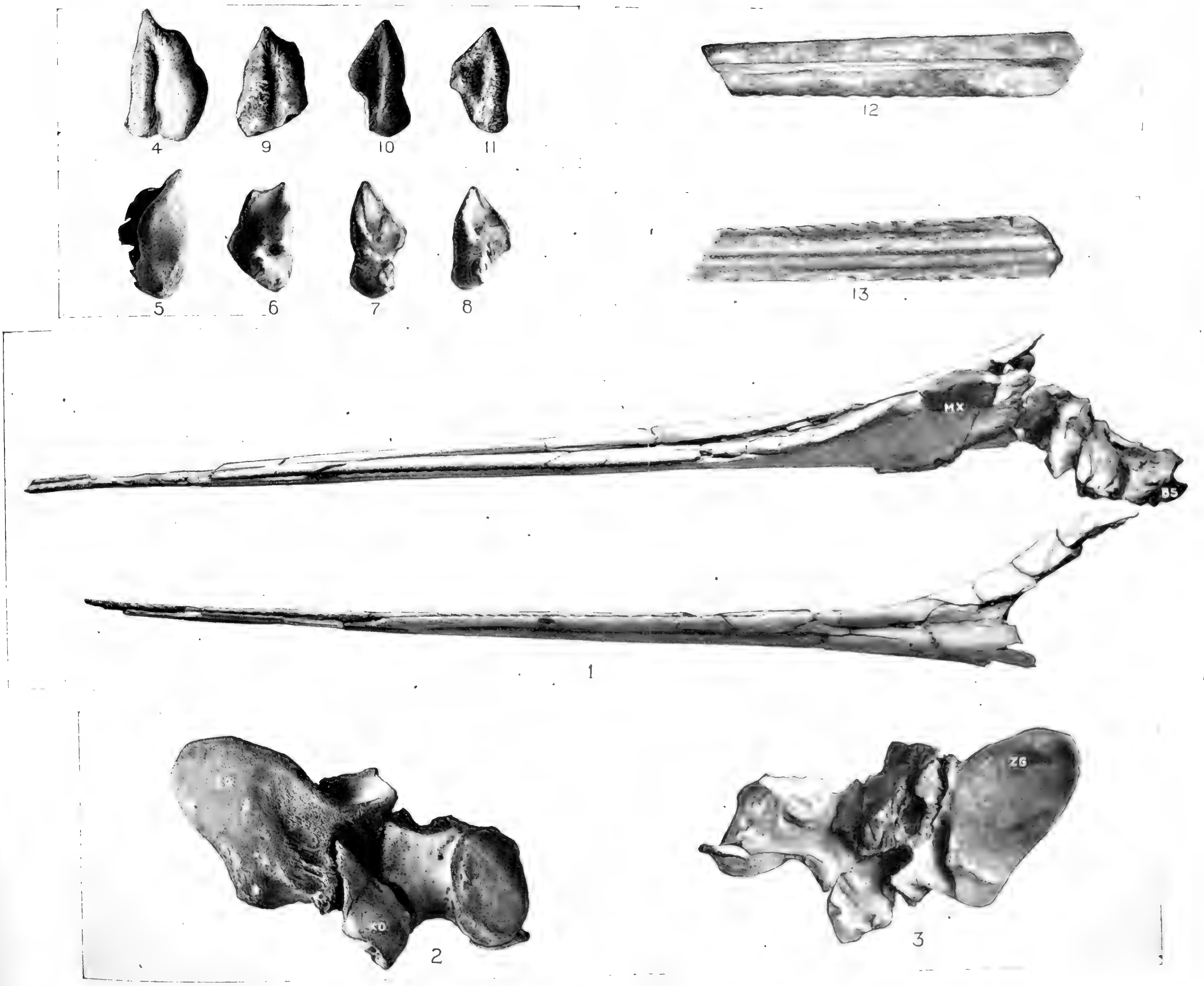
FIG. 12. Fragment of the symphysis of the mandible of *S. crassangulum* from Chesapeake Beach, Md. (In the U. S. National Museum.) Upper surface. One-half natural size.

FIG. 13. The same fragment. Lower surface. One-half natural size.

BS = Basisphenoid.	PT = Pterygoid.
ME = Mesethmoid.	V = Vomer.
MX = Maxilla.	XO = Exoccipital.
PMX = Premaxilla.	ZG = Zygomatic.



SCHIZODELPHIS CRASSANGULUM (CASE)



SCHIZODELPHIS CRASSANGULUM (CASE)

1. CRATER RIM FROM NORTHEAST

2. CRATER RIM FROM SOUTH

THE METEOR CRATER OF CANYON DIABLO, ARIZONA; ITS HISTORY, ORIGIN, AND ASSOCIATED METEORIC IRONS

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HEAD CURATOR OF GEOLOGY, U. S. NATIONAL MUSEUM

(With 15 plates)

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INTRODUCTION

Interest in the question of the possible meteoric origin of the remarkable crater-form depression lying a few miles south of the Santa Fé Railroad and not far from Canyon Diablo, in Coconino County, Arizona, has lately been revived by development work carried on under the direction of the Standard Iron Company of Philadelphia, and the publication of preliminary results and conclusions in the

Proceedings of the Philadelphia Academy of Sciences.[1] Such an origin was considered by Mr. G. K. Gilbert in his paper on the "Origin of Hypotheses," published in 1896, but the facts then available failed, in his opinion, to substantiate so startling a conclusion. The later developments and the interpretations put upon them have reopened the question and in the minds of many proven the correctness of the meteoric hypothesis.[2]

The mere existence of a crater some three-fourths of a mile in diameter and 500 feet in depth in a region of undisturbed sedimentary rocks and remote from volcanoes is in itself enough to invite scientific inquiry, while even the plausible suggestion that such might be due to the impact of a stellar body is of so unusual a nature as to warrant the fullest investigation. Consultation with the authors of the paper above noted impressed the writer with the desirabiliy of a re-study of the problem in the light of the new evidence. The matter was therefore laid before Secretary Walcott, of the Smithsonian Institution. He promptly approved of the general plan of the work, and in May of the present year the writer spent several days on the ground, and has since been in frequent consultation and correspondence with Messrs. D. M. Barringer and B. C. Tilghman, the prime movers in the development work. The results are given in the following pages. The closing down of the works at this time, owing to the approach of winter, furnishes a convenient halting place in the investigation.

II. Geology and Physiography of Region

The region about Canyon Diablo is an elevated and nearly level sandy plain, the floor of which is composed in the main of a buff-colored arenaceous limestone known as the Aubrey (Carboniferous) limestone. This is capped here and there by low, elongated flat-topped mesas of red sandstone, which are but residuals from a one-time continuous stratum that covered the entire area. The limestone is underlaid by a highly siliceous sandstone of a gray or faintly buff tinge (also Carboniferous), and this in turn by a yellow, merging into red, sandstone. The exact thickness at this point of any of these beds can not be given. The U. S. Geological Survey, basing their estimates on results of well borings at Winona, some 30 miles distant,

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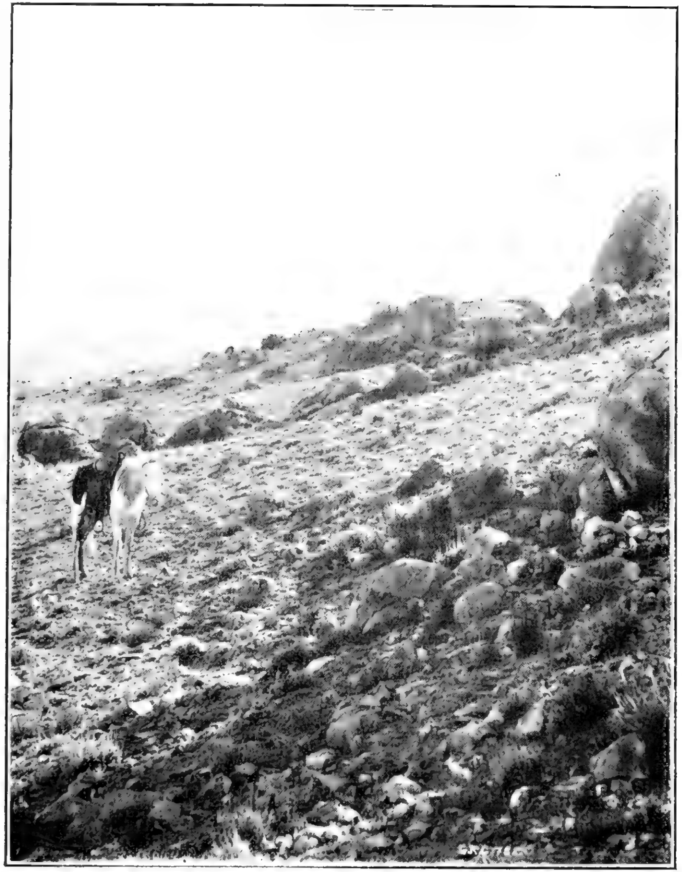
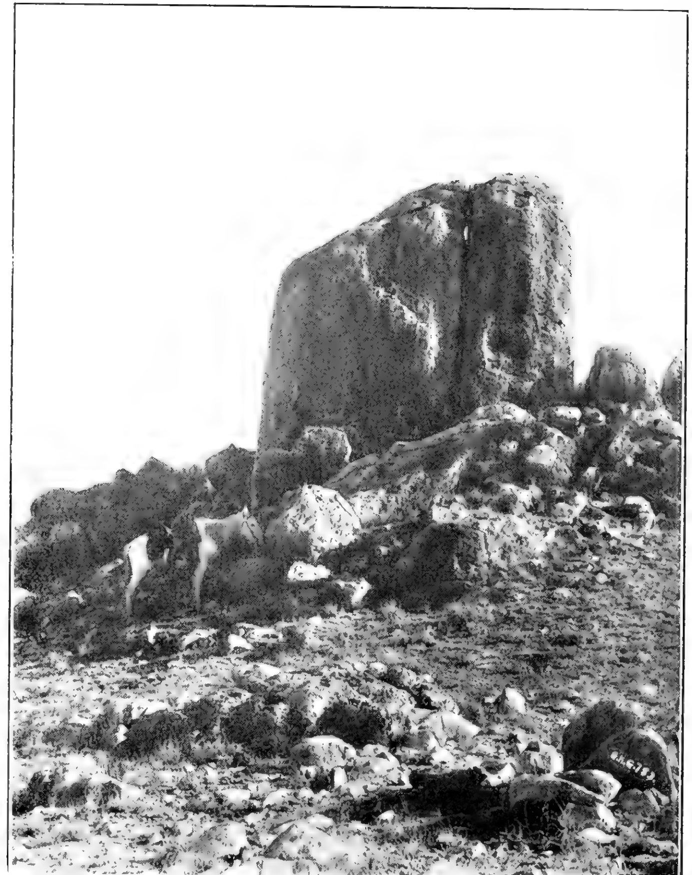
[1] Coon Mountain and Its Crater, by D. M. Barringer, and Coon Butte, by B. C. Tilghman, Proc. Acad. of Sciences of Philadelphia, 1906, pp. 861–914.

[2] At the December, 1906, meeting of the Geological Society of America, in New York, Prof. H. L. Fairchild, of Rochester, submitted some lantern slides of the crater and announced his acceptance of this hypothesis.



1. OUTER SLOPE OF EAST RIM OF CRATER



2. LIMESTONE BOULDER ON OUTER SLOPE OF CRATER

give the Aubrey limestone at Canyon Diablo as probably not far from 300 feet in thickness, the gray sandstone 400 to 500 feet in thickness, and the still lower yellow-red sandstone about 1,000 feet in thickness.[1] The residual overlying red sandstone in the mesas is rarely over 15 to 20 feet in thickness, never, according to Mr. Barringer, over 50 feet. These beds all lie approximately horizontally, and almost as little disturbed by orographic movements and other dynamic agencies than those of erosion as when first laid down. The country is arid, the average annual rainfall being but 8 inches. The dryness of the soil consequent upon this slight precipitation is increased by numerous deep canyons and even earth cracks,[2] which quickly drain off all surface water. The country is essentially a desert, though affording at certain seasons of the year good pasturage for numerous flocks of sheep. Viewed from a slight elevation, and particularly when the sun is approaching the horizon, these great stretches of gray plain, with their scanty vegetation and occasional streaks of red from the residual sandstone mesas, are fascinating in the extreme and well merit the descriptive name of "Painted Desert," as applied by the early explorers of the region to the northwest, of which they are but a continuation.

III. The Crater

Historical References.—The occurrence of a peculiar crater-form depression within an elevated rim of limestone and sandstone, some 5 miles south of the railroad and 12 miles southeast of Canyon Diablo, has been known for several years, but was first brought prominently before the scientific world by A. E. Foote[3] in 1891, and through the later writings of G. K. Gilbert,[4] D. M. Barringer, B. C. Tilghman,[5] and others.

This crater, through a singularly inappropriate use of terms, has become known in the literature as *Coon Mountain,* or *Coon Butte,* although occurring in a region where raccoons are rarely known

[1] The record at Winona, where the limestone had been very considerably eroded, was: Aubrey limestone, 185 feet; light gray sandstone, 456 feet; red sandstone, 16 + feet. (Darton.)

[2] The Canyon Diablo, the Canyon of the Little Colorado, the Grand Canyon of the Colorado, and the earthquake cracks described by Gilbert (Science, vol. II, 1895, p. 117) are sufficient examples of these.

[3] American Journal of Science, vol. XLII, 1891, p. 413.

[4] Presidential Address, Geol. Soc. of Washington, 1896; also Science, vol. III, 1896, p. 1.

[5] Coon Mountain and Its Crater, Proc. Acad. Natural Sciences, March, 1906, p. 861.

and partaking of the nature neither of a mountain nor butte. At best, the elevation is but a low, circular ridge, and in the existing condition of our knowledge might be well renamed Meteor Crater.

External Appearance.—As seen from the railroad and other points within a few miles, the crater rim rises above the level of the plain in the form of a low hill with peculiarities of contour and surface configuration that at once catch the eye of the observant and serve to differentiate it from the surrounding mesas. Its appearance, as viewed from the northeast and from the south, is shown in plate LXI. East and west views differ in detail, which, though of importance in connection with the origin of the crater itself, are not sufficiently conspicuous in the photographs to warrant reproduction.

A near view shows the mass of the crater rim (as the hill proves to be) to be composed, so far as visible, of loose, unconsolidated material in fragments of all sizes from microscopic dust to blocks weighing hundreds of tons (pl. LXII). The jagged nature of the ridge increases until the summit (pl. LXIII) is reached, where a full view of the phenomenon and its surroundings is obtained (see pl. LXIV, figs. 1 and 2)[1]. From this point it is seen that the crater walls are composed of the crushed, broken, and bent strata of the limestone and sandstone forming the floor of the surrounding plain (pl. LXV), and which dip away from it in all directions. In other words, the structure is that which is known as quaquaversal. The crater rim is at its highest point 160 feet above the plain, according to Mr. Barringer, and at its lowest 120 feet. In outline the crater is itself nearly circular, though showing numerous minor deformations (see contour map, pl. LXVI). The diameter along an east to west line is given as 3,808 feet; along a north and south line as 3,654 feet,[2] and the depth as approximately 600 feet from the crest of the rim, though, as will be noted, this is considerably short of the original depth.

Details of Structure.—As already noted, the crater rim is composed exteriorly, so far as exposed to view, of loosely consolidated fragmental material, for the most part angular, and beyond ques-

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[1] The view from this point, particularly about sundown or by moonlight, is weird and impressive in the extreme. The inwardly steep and even overhanging walls, profoundly shattered, surrounding on every side a broad, deep pit, accessible only by the steepest of trails, barren of all but the scantiest of vegetable life and gashed by torrential action, present a picture which, when one reflects on its probable origin, is never to be forgotten.

[2] Later measurements by Mr. Lombard, of Flagstaff, give the major diameter as 3,950 feet and the lesser 3,850 feet.

1, 2. LOOKING NORTHWARD ALONG CREST OF WEST RIM OF CRATER

1. LOOKING ACROSS THE CRATER FROM NORTHERN RIM

2. LOOKING ACROSS AND INTO THE CRATER FROM THE SOUTH

tion derived from what is now the crater interior. Masses of sandstone and limestone, from the finest rock-flour to those weighing hundreds and even thousands of tons, are scattered about in the wildest profusion (see pls. LXII and LXIII). The larger blocks are of limestone, but this, as noted by Gilbert, is due to the rapid disintegration of the sandstone under atmospheric influences. They are most abundant on the east and west slopes, and lie on or near the crest of the rim, from which the debris spreads out in gradually diminishing quantities for distances varying from one-fourth of a mile to nearly a mile, or in some instances, according to Gilbert, to a distance of 3½ miles. The block shown in figure 12 of Mr. Gilbert's paper is described as 10 feet in height and as lying some half a mile outside of the crater rim. Perhaps the most significant feature of the ejectamenta is the occurrence of enormous masses of the sandstone which have undergone a partial metamorphism through crushing and heat in a manner to be described when speaking of the materials found inside of the crater. It is sufficient to state here that this material must have come from a depth of at least 300 feet below the original surface. In this connection may be mentioned also the rock-flour ("silica" of Mr. Barringer's paper), which, while occurring on nearly all sides of the crater, is particularly conspicuous on the southern slope, where it has been cut through by a dry "wash," and is exposed for a distance of hundreds of feet to a depth in some cases of upward of 10 feet (see pl. LXVII, fig. 1). This is of a chalky white color, has a sharp, gritty feeling when rubbed between the thumb and fingers, and, as shown by the microscope, is composed of the shattered grains of the gray sandstone. It will also be described in detail later.

At various points along the lower margin of the crater, and particularly toward the north, are many low, rounded, moraine-like deposits composed of the same material as the rim, but for the most part in a comparatively fine state of disaggregation (see pl. LXVIII, fig. 1). In pits and trenches, sunk in these, are found fragments of all the rocks indigenous to the crater, and, what is of still greater interest, many of the shale-ball irons described elsewhere[1] and first brought to notice by Mr. Barringer. The occurrence of these is fully described by Mr. Barringer, and subsequent excavations made in the writer's presence corroborated his description in every

[1] See also Contributions to the Study of the Canyon Diablo Meteorites by George P. Merrill and Wirt Tassin, Smith. Misc. Collections (Quarterly Issue), vol. 50, p. 203, September, 1907.

detail. The position they occupy is such as can be accounted for only on the supposition that all the material composing the deposit was in the air at the same moment of time and was deposited "pell mell," wholly without order or reference to gravity, as it fell to the ground. Mr. Barringer speaks of one mass of the iron, found some 6 feet beneath the surface, embedded mainly in the fine white rock-flour ("silica") and directly beneath an angular fragment of red sandstone several feet in diameter, overlying which was a piece of limestone, and over this again one of sandstone.

The rim of the crater is, as stated, at its highest point some 160 feet above the surface of the plain, with a very conspicuous low place (see pl. LXIV) on its northern side. The 5,800-foot contour line (see pl. LXVI) passes along this crest, and it is seen that on the north, and for the most part on the east and south, this is a mere ridge (pl. LXIII, fig. 2) sloping away abruptly on either hand. To the west and southwest the 5,800-foot contour includes two long and comparatively broad areas, near the middle of the southwestern of which are found the highest points on the rim—5,860 and 5,863 feet. The supposed significance of these features of the crest will be noted later.

A glance at the interior walls of the crater shows at once its nature, if not origin (see pls. LXV and LXIX). The details have been given very fully by Messrs. Barringer and Tilghman and less so by Gilbert. They consist of strata, principally of the limestone, but locally of sandstone also, "crushed and shattered to an extraordinary degree" and dipping away (*i. e.*, outward) on all sides at angles of from 10° to 80°, or, in one instance, with an overturn of at least 10° from the vertical. The walls are steep and often overhanging, for hundreds of feet accessible but to birds, and of so loose and friable a character as to make exploration dangerous. A single false step may set tons of loose material slipping and plunging down the steep slope. The illustrations utterly fail to convey an idea of their impressive as well as dangerous character. The typical sections here given were made by Mr. Tilghman, to whom I am indebted for the privilege of utilizing them. It will be noted that at Station 5 (see diagram, figs. 124 and 125) the crater wall is composed, below the surface debris, of (1) a thin bed of red sandstone, and (2) the Aubrey limestone, dipping southwesterly 35°, the cliff face sloping inward at an average angle of 34°. The underlying white sandstone does not show at this point, being obscured by talus fallen from the cliffs above and the sedimentary beds formed in the bottom of the crater. The "typical east rim" section (Station 18, fig. 125)

1. INTERIOR WALL OF CRATER, LOOKING NORTHWARD

2. LOOKING ACROSS CRATER FROM NORTH, SHOWING FAULTING (BENEATH ARROW) IN SOUTHERN RIM

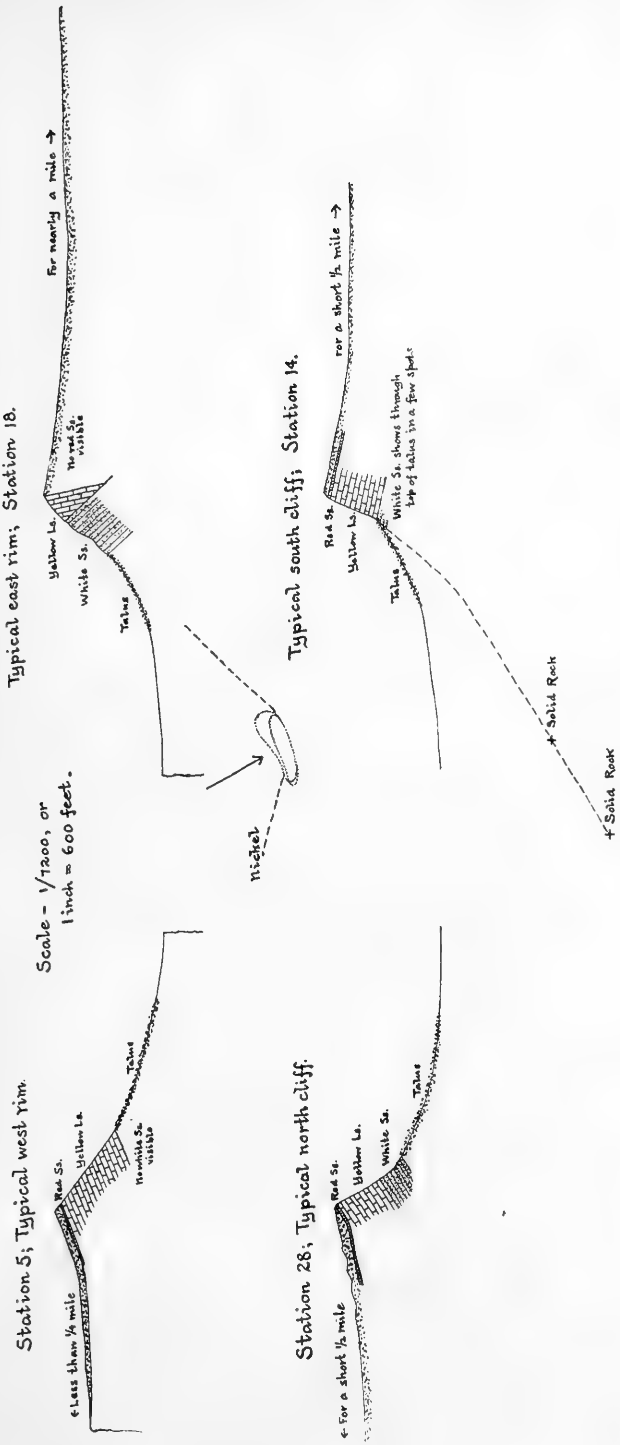


Fig. 124.—Cross-sections of Crater. From drawings of Mr. Tilghman.

is by far the most striking and suggestive of the series. No red sandstone is here visible. The limestone is shattered and turned up at an angle of 80°, the cliff face having an average slope of about 46°. Immediately beneath this appears the white sandstone, at first crushed to powder, but beneath gradually assuming a more solid form, until at the bottom of the outcrop it is nearly normal in ex-

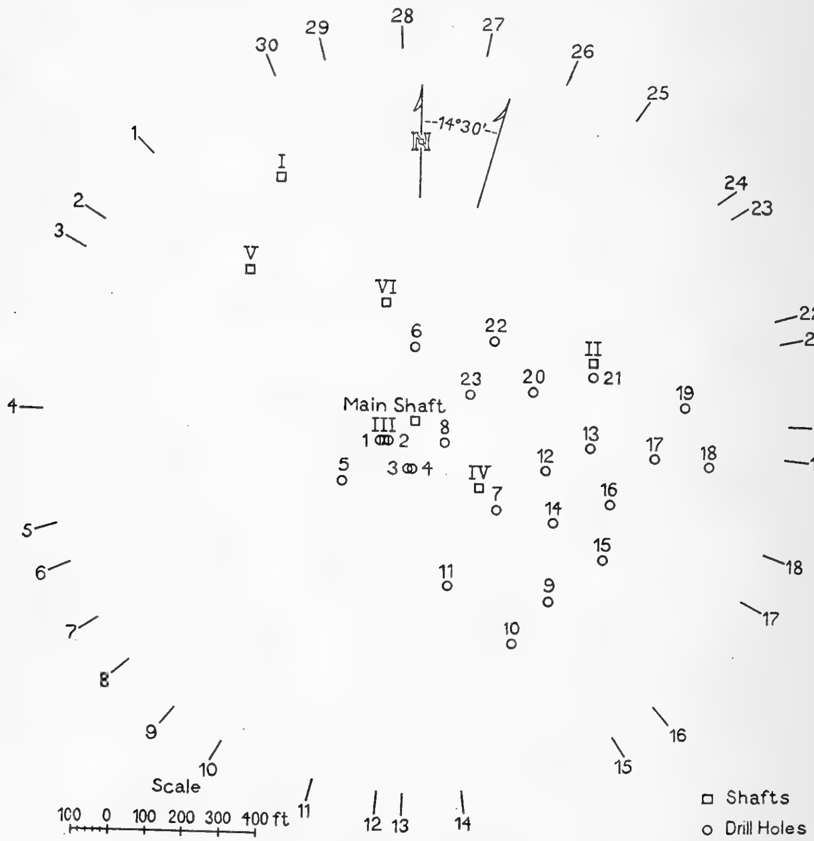
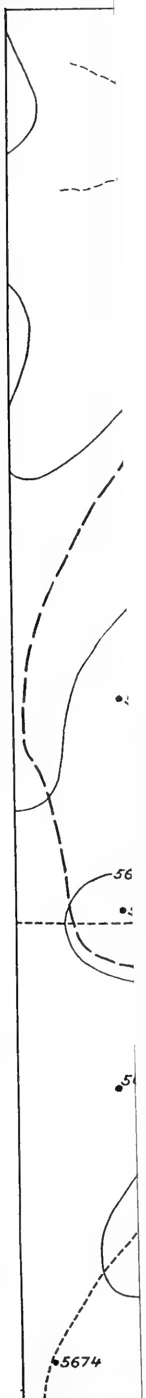


FIG. 125.—Diagram Showing Position of Drill Holes and Shafts in Bottom of Crater.

ternal appearance. This, too, dips away at a high but smaller angle than the limestone, which is undoubtedly faulted against it, as shown in the sketch. An almost equally interesting point in the rim is that at Station 16 (S. 56° E.), where the sandstone in the face of the cliff is faulted up so as to abut squarely against the limestone, the beds to the northeast having a dip of 44°–54°, while those to the southwest lie at angles of but 6°–20°. This vertical fault is shown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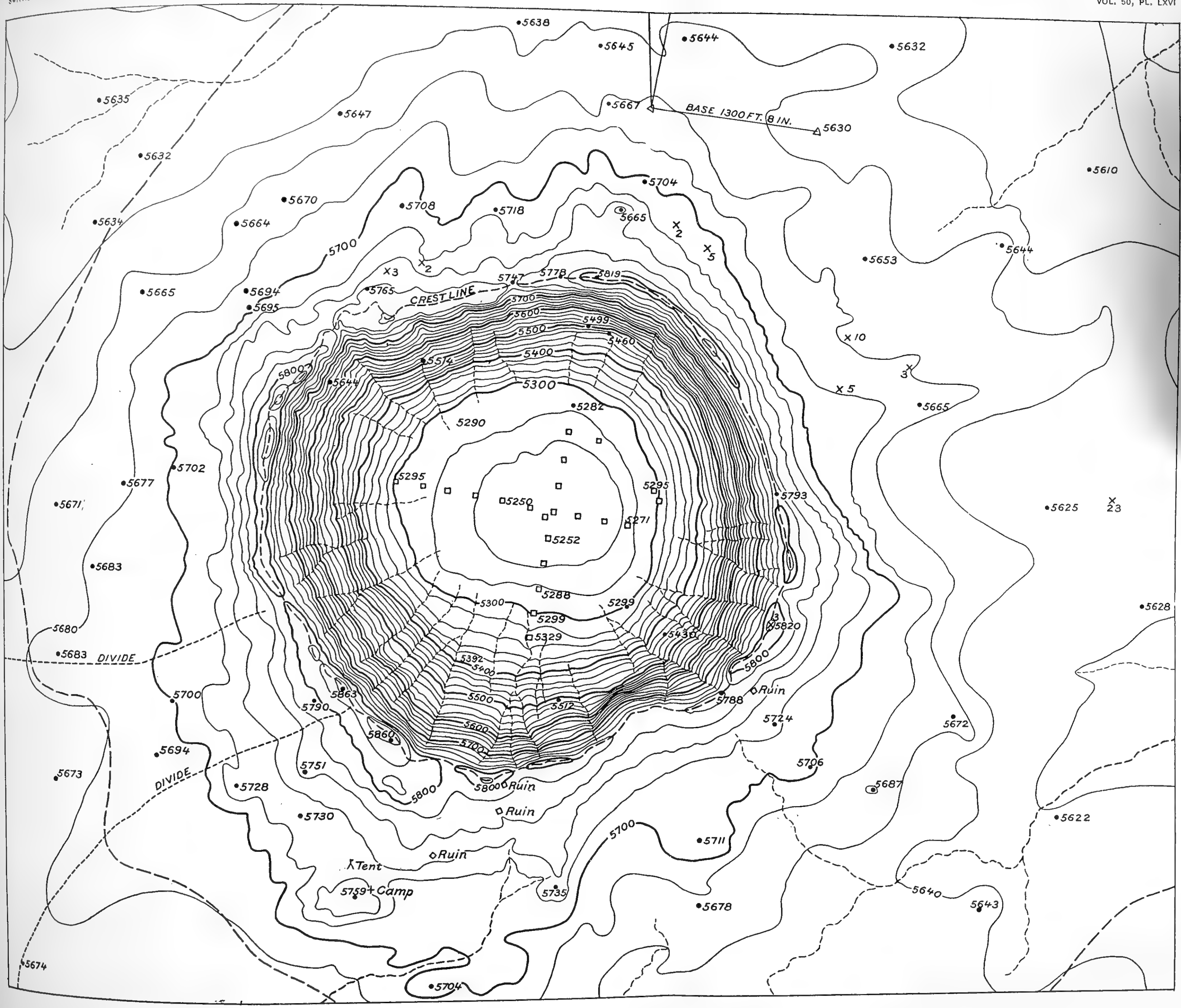


CONTOUR MAP OF CRATER, CANYON DIABLO, ARIZONA

somewhat indistinctly at the point directly beneath the arrow in fig. 2, pl. LXV.

The "typical North Cliff" section (Station 28) shows again a thin bed of red sandstone underlying the surface debris, dipping outward at an angle of 36°, under which is the yellow limestone lying nearly at the same angle, and beneath this again the white sandstone. The slope of the cliff facing the crater is here 49° to 60°. The "typical South Cliff" (Station 14) shows likewise the red sandstone and yellow limestone dipping at angles of 12° to 14°, with the angle of slope of the interior wall standing as high as 76°. A very little white sandstone shows through the top of the talus beneath the limestone.

These examples are sufficient to convey an idea of the remarkable character of the crater walls. The following table from Mr. Tilghman's notes is, however, inserted (compare fig. 125):

Sta. 1,	north 60° W.,	dip; red sandstone,	15°;	limestone, inaccess.	cliff,	76°, av.
" 2,	" 73° W.,	" " "	30°;	" 19°	"	50°, "
" 3,	" 78° W.,	" " "	....	" ...	slope,	40°, "
" 4,	south 76° W.,	" " "	....	" 35°	"	35°, "
" 5,	" 58° W.,	" " "	....	" 35°	"	34°, "
" 6,	" 52° W.,	" " "	17°;	" 20°	"	34°, "
" 7,	" 42° W.,	" " "	covered up;	" 54°	"	34°, "
" 8,	" 34° W.,	" " "	....	" broken, 75° 85° 95°	"	50°, "
" 9,	" 24° W.,	" " "	7°;	" ...	"	...
" 10,	" 15° W.,	" " "	10°;	" 16°	"	41°, "
" 11,	" 0° W.,	" " "	13°;	" 15°	"	37°, "
" 12,	" 10° E.,	" " "	16°;	" 28°	"	44°, "
" 13,	" 14° E.,	" " "	10°;	" 8°	cliff,	66°, "
" 14,	" 23° E.,	" " "	12°;	" 14°	"	76°, "
" 15,	" 48° E.,	" " "	3°;	" —3°	"	...
" 16,	" 56° E.,	fault { west of fault east of fault		" 6°–20° " 44°–54°	slope,	33°, "
" 17,	" 77° E.,	" " "	none;	" 45°–80°	"	40°, "
" 18,	" 85° E.,	all broken up—no red sandstone,		about 80°	"	46°, "
" 19,	north 80° E.,	too broken to measure;		limestone, " 60°	"	43°, "
" 20,	" 75° E.,	dip; red sandstone,	9°–12°;	" " 28°	"	50°, "
" 21,	" 62° E.,	" " "	28°;	" " 45°	"	54°, "
" Ext.,	" within few feet;	" "		" " 75°–90°	"	...
" 22,	" 58° E.,	dip; " "	53°;	" " 50°	"	41°, "
" 23,	" 42° E.,	" " "	....	" 33°	"	46°, "
" 24,	" 38° E.,	" " "	28°;	" 36°	"	46°, "
" 25,	" 20° E.,	dip; red sandstone,	14°;	" 26°	"	44°, "
" 26,	" 8° E.,	" " "	20°;	" 34°	"	40°, "
" 27,	" 5° W.,	" " "	44°;	" 42°	"	42°, "
" 28,	" 18° W.,	" " "	36°;	" 37°	{ cliff, slope,	60°, " 49°, "
" 29,	" 30° W.,	" " "	36°;	" 29°	{ " cliff,	50°–52°, " 70°, "
" 30,	" 38° W.,	" " "	6°;	" 7°	{ " slope,	71°, " 60°, "

IV. The Crater Floor

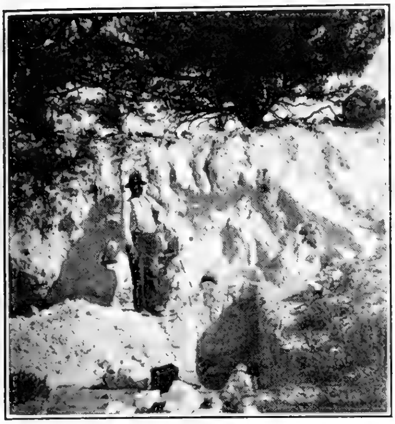
Physiography.—As already noted, the crater has at present a maximum depth of 600 feet, measured from the crest of the rim, or about 440 feet below the level of the plain. Beyond the fringing reef of talus the floor presents a nearly level plain of over 300 acres in extent, surrounded on all sides by well-nigh inaccessible cliffs (see pls. LXIX and LXX). It needs but a glance, however, to show that a large amount of material has fallen from the interior walls through the action of gravity, water, and frost (pl. LXVIII, fig. 2), and that the original depth must have been considerably greater. How much greater could be only guessed at until the borings incident to the development work of Messrs. Barringer and Tilghman were undertaken. A number of drill-holes have now been sunk to depths up to 1,100 feet, and from the results thus obtained we are enabled to gain a record entirely inaccessible at the time Mr. Gilbert made his studies, and which throws such light upon the subject as to justify us in reverting once more to the original hypothesis, as set out in Mr. Gilbert's paper and advocated by Messrs. Barringer and Tilghman—that of an origin through impact of a giant meteorite.

Results of Borings.—Below are given the results of one of these borings (hole No. 17), situated 600 feet south, 84° east (true) of the center of the crater and starting on a surface 540 feet below the rim, or 400 feet below the level of the plain. (See fig. 125.)

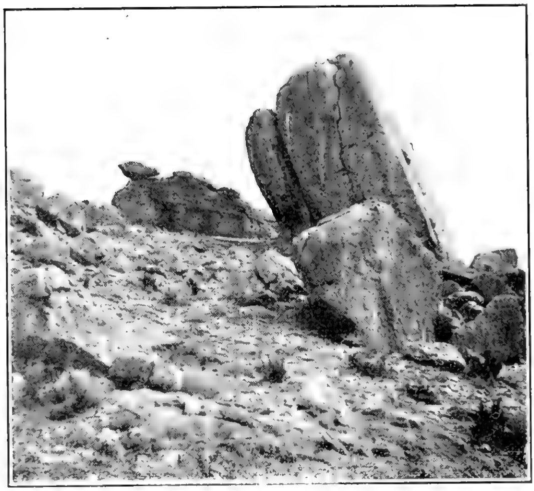
	Feet.
(1) Surface material, soil, sand, and wash from cliffs	0– 27
(2) Lake-bed formations, lying horizontally and containing diatoms, shells of mollusks, and abundant gypsum crystals	27– 88
(3) A sand which gives reaction for nickel and iron and contains fragments of metamorphosed sandstone, sandstone pumice, etc.	85–220
(4) Sand and rock, sand grains crushed slightly, if any, and not metamorphosed, barren of meteoric material	220–520
(5) Sand and "silica" (rock-flour), with abundant slag-like material containing iron and nickel, and metamorphosed sandstone	520–600
(6) Fine silica powder (rock-flour) and sand, no meteoric material	600–620
(7) Bed-rock, a grayish sandstone rapidly becoming yellow and harder, not metamorphosed	620–720

A less detailed record of hole No. 12 is as follows:

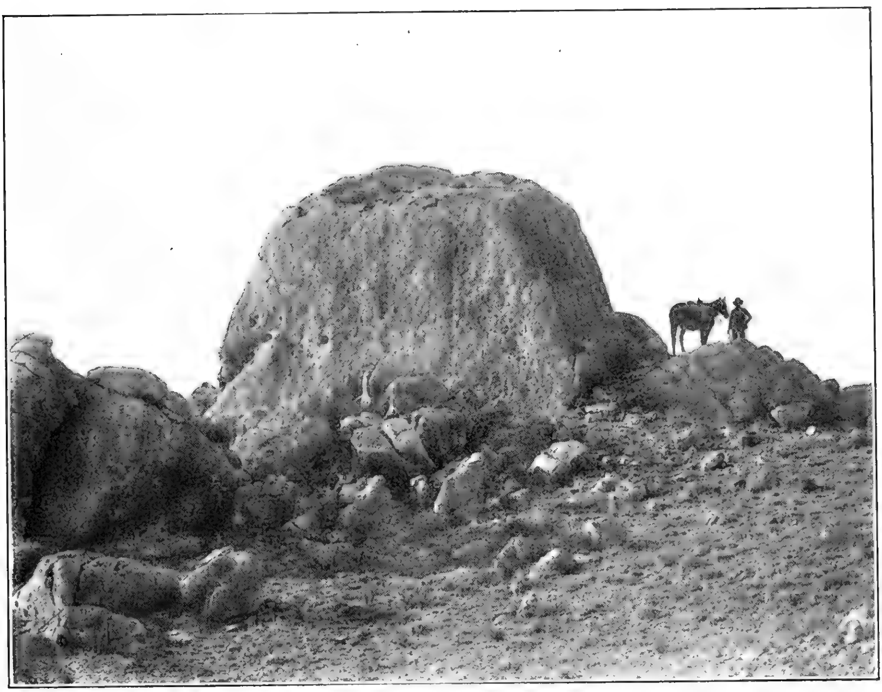
(1) Surface soil, blown sand, etc.	0– 30
(2) Lake-bed deposits	30– 90
(3) Sand (rock-flour), sandstone in part metamorphosed	90–630
(4) Rock, at first soft and shattered, but becoming gradually harder as greater depths were reached	630–830



1. DRY WASH, SOUTH SIDE OF OUTER RIM



2. WHALE ROCK ON WEST RIM



3. BOULDER ON RIM OF CRATER, WEST SIDE

1. MORAINE-LIKE HILLS ON NORTHERN RIM OF CRATER

2. INTERIOR WALLS OF CRATER, WITH TALUS AND ALLUVIAL FANS FROM CLIFFS

The yellow to red sandstone, which seems everywhere to form the floor of the crater, was first struck at a depth of 820 feet. Meteoric material—*i. e.*, material reacting for nickel and iron—was first encountered at a depth of 180 feet, and continued with few exceptions in all samples down to 600 feet.

A like record of other holes is as below:

No. 7	yielded	material	reacting	for	nickel	at	depths	of	450–550 feet.
No. 12	"	"	"	"	"	"	"	"	595–640 "
No. 13	"	"	"	"	"	"	"	"	598–660 "
No. 14	"	"	"	"	"	"	"	"	540–620 "
No. 15	"	"	"	"	"	"	"	"	[1]590–600 "
No. 16	"	"	"	"	"	"	"	"	540–620 "
No. 17	"	"	"	"	"	"	"	"	520–580 "
No. 20	"	"	"	"	"	"	"	"	640–680 "
No. 21	"	"	"	"	"	"	"	"	620–640 "
No. 22	"	"	"	"	"	"	"	"	600–620 "
No. 23	"	"	"	"	"	"	"	"	520–620 "
No. 24	"	"	"	"	"	"	"	"	550–650 "

The following table in connection with figures 124 and 125 is instructive as showing the condition of the deeper lying beds and the varying depths at which what could be unmistakably identified as the underlying red beds were reached:

Hole No.	Red beds found at depths of—	Total depth of hole.	Remarks.
5	885 feet........	1,003 feet......	
6	890 feet........	1,059 feet......	Solid cores obtained below 1,030 feet.
7	905 feet........	960 feet........	
8	900 feet........	1,085 feet 7 in..	Solid cores obtained below 1,030 feet.
9	Not reached ...	670 feet........	
10	" " ...	745 feet........	Solid rock below 640 feet.
11	830 feet........	830 feet........	" " " 640 feet.
12	875 feet........	881 feet........	" " " 700 feet.
13	Not reached ...	740 feet........	" " " 640 feet.
14	" " ...	780 feet........	" " " 670 feet.
15	" " ...	750 feet........	" " " 650 feet.
16	" " ...	750 feet........	" " " 640 feet.
17	" " ...	720 feet........	" " " 600 feet.
18	" " ...	660 feet........	" " " 630 feet.
19	" " ...	680 feet........	" " " 620 feet.
20	" " ...	780 feet........	" " " 720 feet.
21	" " ...	760 feet........	" " " 660 feet.
22	860 feet........	860 feet........	" " " 650 feet.
23	Not reached ...	800 feet........	" " " 660 feet.

These records are sufficiently characteristic to serve our purpose. It is evident that the bottom of the crater was occupied at one time by a shallow lake, in which lived diatoms and fresh-water mollusks,

[1]Traces only.

and on the bottom of which accumulated, during periods of drought, the deposits of carbonate of lime and gypsum so characteristic of the playa lakes of the West. This naturally thins out along the margin where it overlaps the fragmental material from the steep slopes. None of this needs attention in the discussion of the present problems. The crushed and metamorphosed white sandstone under-

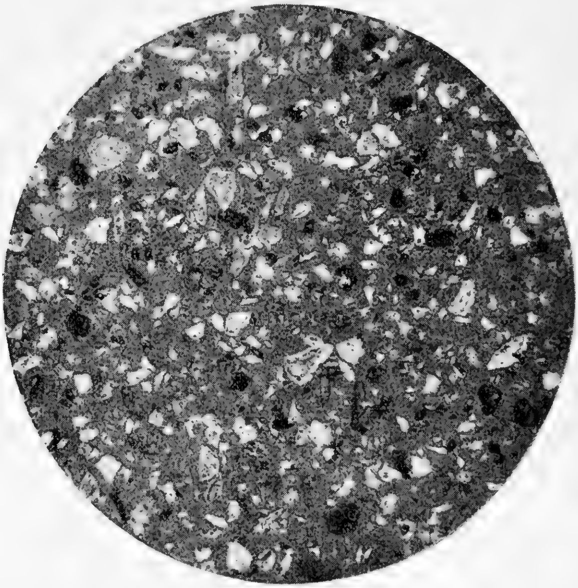
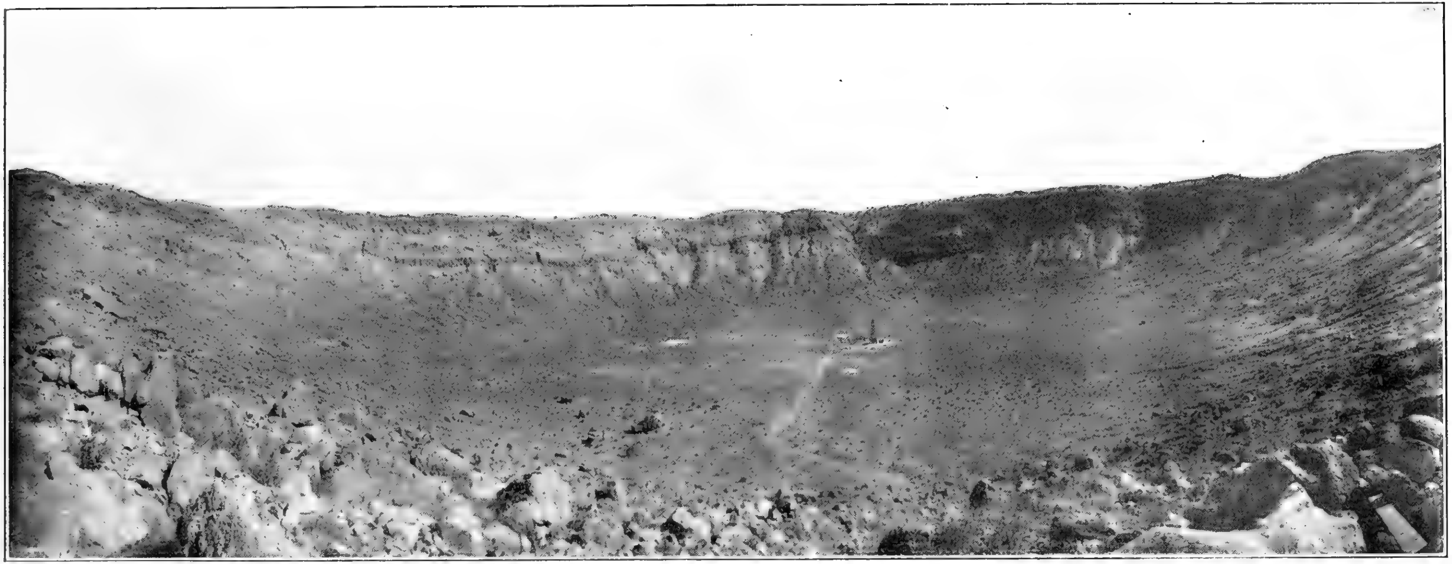


FIG. 126.—Showing the Microstructure of the Rock Flour. The angular particles are all of quartz.

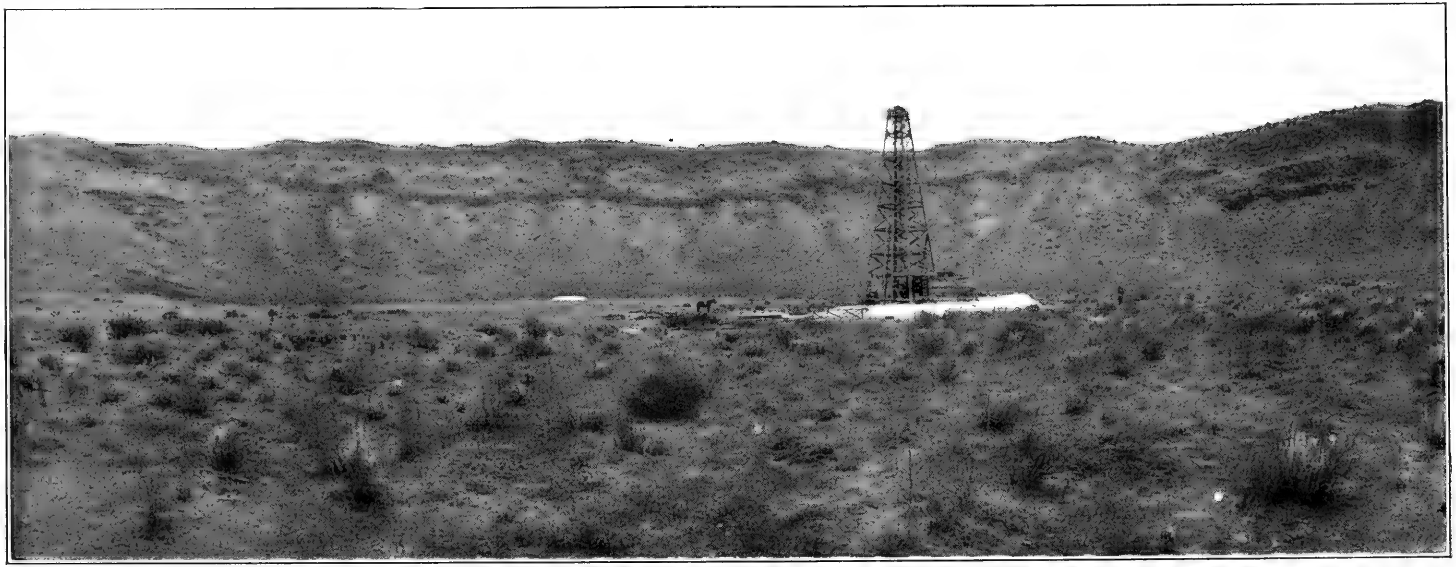
lying it needs, however, careful consideration. This has been already the subject of brief notice by the writer,[1] but is of sufficient importance, as bearing upon the matter of origin of the crater, to be elaborated here.

Petrographic Description of Rock Products.—The unaltered gray sandstone, which has already been referred to as underlying the limestone and having an approximate thickness of 400 or 500 feet, is in its typical form of a very light gray or nearly white color, and is composed wholly of well-rounded, clear, colorless grains of quartz sand, with an occasional fragment of feldspar. A photomicrograph of this is given in figure 1, plate LXXI. This rock, as shown in the borings and as noted in the description of the crater walls, is often much shattered and crushed and is found in

[1]On a Peculiar Form of Metamorphism in Siliceous Sandstone, Proc. U. S. Nat. Mus., vol. XXXII, 1907, pp. 547–550.



INTERIOR OF CRATER, SHOWING NEARLY LEVEL FLOOR, LOOKING SOUTH



INTERIOR OF CRATER SHOWING NEAR VIEW OF SOUTH WALL

all gradations, from that just described to the white, almost dust-like powder designated as "silica" by Messrs. Barringer and Tilghman, but which the writer of this paper will refer to as rock-flour. This, interspersed with more or less firm material, occupies a large portion of the crater from the 85- or 90-foot level down to the underlying red bed, a distance in round numbers of 500 feet. It is found also wherever pits have been sunk on the exterior margin of the rim and in deposits comprising the thousands of tons of material shown in figure 1 of plates LXVII and LXVIII. Between the thumb and fingers this material, notwithstanding its fineness, has a sharp gritty feeling, and under the microscope is seen to be composed wholly of the sharply angular bits of quartz derived from the shattering of the individual grains of sand (see fig. 126). It has been unquestionably derived from the sandstone, and that, too, not by simple disintegration, but through some dynamic agency acting like a sharp and tremendously powerful blow.

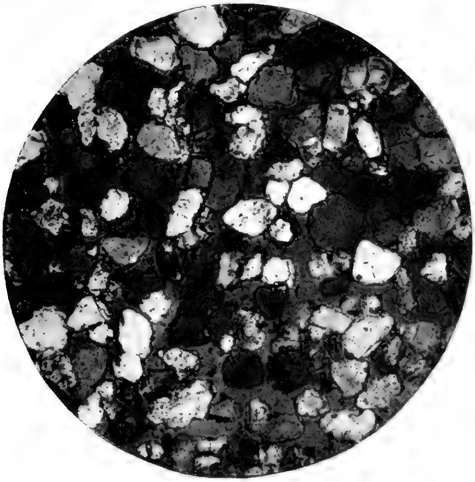
Commingled with this material in the bottom of the crater (as shown by shafts), and to a less extent around the margin and in scattered masses outside of the rim, are fragments of what is plainly sandstone, but of an almost snow-white color, and so friable as to be readily crushed between the thumb and fingers (locally known as *ghost sandstone*). With these, but less abundant, are more compact, but platy forms, almost devoid of appreciable granular structure, but which were yet recognized by Messrs. Barringer and Tilghman as sandstone derivatives, and, more rarely yet, some coarsely and finely pumiceous forms, the exact nature of which was uncertain. These last were examined by Mr. Diller and reported upon to Mr. Gilbert at the time he was making his studies, but the results were not published.

The following is an amended description of these crushed and otherwise altered forms as given by the author in his paper above referred to:

The sandstone (Cat. No. 76,834, U. S. N. M.) in its original and prevailing type is of a light-gray color, distinctly saccharoidal and, in the walls of the crater, very friable, being in small masses easily disintegrated in the hands. Under the microscope it is found to be composed of well-rounded quartz granules, with an occasional grain of a plagioclase feldspar, and a little dust-like material in the interstices, but the amount of interstitial material of any kind is very small. The general structure of the stone is shown in figure 1, plate LXXI. This type passes into what may be called the first phase of the metamorphism, an almost chalky white rock (Cat. No.

76,835, U. S. N. M.), still retaining the granular character and much of the original structure of the sandstone, but crushing readily between the thumb and fingers. Under the microscope this type shows interesting structural changes which are only in part brought out by the photomicrograph reproduced in figure 2, plate LXXI. A portion of the quartz granules retain their original characteristics. A larger portion are crushed and more or less distorted, though retaining their limpidity and high polarization colors. In many instances two adjacent granules are crushed and fractured at point of contact, as though they had been struck a sharp blow with a hammer. This crushing has at times been carried so far that the rock is reduced to a fine sand or flour (Cat. No. 76,840, U. S. N. M.), each particle of which is as sharply angular as though disintegrated by a blast of dynamite (see fig. 126). Of greater significance from the present standpoint is the presence in the still firm rock of a large number of granules which are so completely changed as to give rise to forms at first glance scarcely recognizable as quartzes at all. A description of these is given in the discussion of the next or second phase of the metamorphism.

In this second and very complete phase the original granular structure of the sandstone has almost wholly disappeared. The rock (Cat. No. 76,837, U. S. N. M.; fig. 1, pl. LXXII) is chalk white to cream yellow in color, quite hard, though in thin fragments readily broken between the thumb and fingers, and lacks entirely the arenaceous structure. It resembles the decomposed chert quarried at Seneca, Missouri, under the name of tripoli, more than any other rock that the writer can call to mind, although on casual inspection it might readily pass for an old siliceous or calcareous sinter. This material, Mr. Tilghman writes, occurs sporadically throughout the pulverulent material, of which it constitutes some 2 per cent in bulk, and in fragments from the fraction of an inch to 10 or 12 feet in diameter. In one instance the drill passed through a body of it some 50 feet in thickness at a depth of 500 feet below the surface. In the mass this variety shows an uneven platy structure extending across the original, almost obliterated, lines of bedding. The general structure as seen in thin-sections is shown in figure 3, plate LXXI. At first glance such would be pronounced to be a holocrystalline rock. It is in fact an aggregate of closely interlocking quartz granules with low and very uniform relief, dull colors of polarization, and in the majority of instances a marked rhombohedral cleavage. So striking are these features that at first the true nature of the mineral was not recognized. Extinctions are often undulatory, indicating a condition



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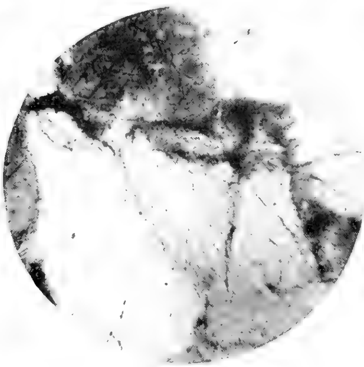

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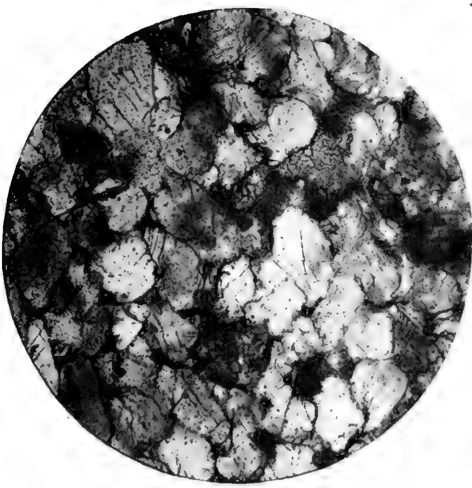

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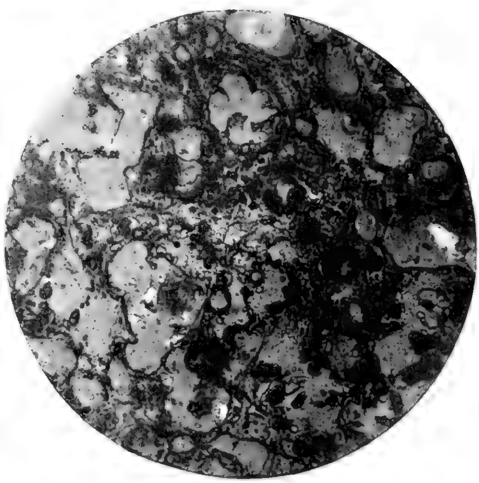

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MICROSTRUCTURE OF GRAY SANDSTONE

See explanation of plates, page 498

of molecular strain, and the cleavage lines are themselves at times more or less wavy (fig. 5, pl. LXXI). The appearance indeed is such as to suggest that the granules have been subjected to pressure while in an almost putty-like or plastic condition. With a high power and between crossed nicols the rock is seen to be not holocrystalline, but to contain comparatively small colorless interstitial areas, showing by ordinary light a fibrous, scaly structure, but which are for the most part completely isotropic between crossed nicols and which the chemical analysis suggests may be opal. From this condition the rock passes through more or less vesicular (fig. 2, pl. LXXII) to highly pumiceous forms (Cat. Nos. 76,839 and 76,840, U.S.N.M.), showing to the unaided eye all the features of an obsidian pumice, but of a white color (figs. 3 and 4, pl. LXXII). This under the microscope is resolved into a colorless vesicular glass, more or less muddied through dust-like material (fig. 4, pl. LXXI), and showing here and there residual particles of unaltered quartz. The glass does not, however, resemble the glass of a pumice, nor is it like that obtained by the artificial fusion of quartz in the geophysical laboratories of the Carnegie Institution. So far as the writer's observations go, it more closely resembles fulgurite glass, formed by the lightning striking in siliceous sand. It is evident that the original molten material was in a highly viscous, almost dough-like condition. The cavity walls are stringy rather than smooth, as in ordinary pumice, and rough fibers or strings of true quartz glass stretch from wall to wall, as shown somewhat indistinctly in figure 3 of plate LXXI. This form, it is well to note, is not abundant and is the material first met with in what Mr. Barringer has designated as shaft No. 2 and at a depth of 130 feet below the crater floor. A few small pieces were found in digging the open cuts outside of the crater, and others lying out on the surface.

Chemical tests on (I), the unaltered sandstone; (II), what may be called the crystalline variety, the finely laminated stone compared to a decomposed chert, and (III), the pumice, gave Mr. Tassin results as below:

(I) Unaltered sandstone	SiO_2	99.29
	Undet.	0.71
		100.00
(II) Altered sandstone	SiO_2	98.63
	Al_2O_3	0.18
	Fe_2O_3	0.10
	Ign	0.99
	Loss at 100°	0.30
		100.20

(III) Pumiceous variety	SiO_2	95.22
	Al_2O_3	0.59
	Fe_2O_3	0.19
	CaO	1.99
	Ign	1.20
	Loss at 100°	0.40
		99.59

The lime in analysis III was there as a mechanically admixed carbonate. The high ignition (0.99) in II would suggest that a part of the silica is in the condition of opal, as already noted. Eliminating the ignition and the free calcium carbonate in III, it is evident that there is no essential chemical difference in the three samples. They vary as little as would probably three independent analyses of any one of the types from slightly different sources.[1]

The distribution about the crater of this altered sandstone is of primary importance. The occurrence of the silica powder (rock-flour) in the dry wash on the south side has been already referred to. Mr. Barringer states that the same material is met with almost anywhere in digging on the outside of the rim, and the shafts and trenches sunk show it to extend to a depth of at least 48 feet, commingled with fragments of limestone and sandstone, both unaltered and in the white, pulverulent condition. As described, it has "evidently welled out of the crater almost like liquid mud, or, perhaps more accurately, like flour when it is poured out of a barrel" (p. 870).

The present writer dug fragments of the altered, white, friable sandstone from trenches on the north side, and the same material from the floor of the low place in the north crest of the rim. The finely pumiceous, almost wholly glassy material, the rarest of all, has been found only in shafts sunk from the bottom of the crater, but the coarser material was found in small quantities well out on the lower slopes to the south. The chemical and petrographic work of Messrs. Melville and Diller, elsewhere referred to, was done on material found on the surface and outside of the crater rim.

The work of boring, as carried on in the interior of the crater, was done with a toothed, hardened steel bit, giving a 2½-inch core. Throughout the 500 feet of crushed sandstone a large portion of the material was washed up by a current of water in the form of loose

[1] At the time Mr. Gilbert was making his investigations a chemical analysis was made by W. H. Melville of the vesicular variety (No. III). This Mr. Gilbert has placed in my hands. It is as follows: SiO_2, 89.71; Al_2O_3, 1.20; FeO, 0.34; CaO, 4.22; MgO, 0.22; K_2O, 0.15; Na_2O, 0.24; Co_2, 3.25; Ign., 0.74; loss at 100°, 0.20; total, 100.27.

sand. A part of this was nickel-bearing, as noted in the record given of the borings, and in some instances, notably holes No. 16 and 20 (Fig. 125), carried metallic particles. The presence of this nickel-bearing sand was naturally of great significance, and attempts were made to isolate the nickeliferous mineral in order to ascertain its possible meteoric character. The white sand showed numerous slag-like granules, which, in the section, were found to be composed of sand grains cemented by iron oxides, and larger granules (½ mm.) of a greenish color, the nickel reaction being limited to the latter. Examined under the microscope, these proved to be aggregates of fine angular bits of the quartz sand, stained by a greenish, amorphous material, concerning the true nature of which the microscope revealed nothing.

Hole No. 17 yielded at a depth of 520 feet abundant sand grains stained brown-red by iron oxides and commingled with it occasional minute—perhaps 1 mm. in diameter—thin metallic scales, which it was at first thought might have come from the drill, but which Mr. Tassin's tests showed to consist of phosphide of iron and to be unquestionably schreibersite and of meteoric origin. Small scales of nickel-iron were also found,[1] and in one instance (hole No. 16) a number of chromite and fayalite (?) granules. The source of these last is conjectural, since neither mineral has thus far been identified in the meteoric iron, though Derby gives a trace of chromium in the analysis noted later. Careful search was made for anything in the nature of a silico-ferruginuous slag, such as it was conceived might result from the mutual fusion of sand grains and meteoric iron. Nothing was found that could be thus positively identified until hole No. 20 was reached, though some of the particles showed in thin-section a very deep green or brownish, blebby glass which it was at first thought might be particles of the volcanic sand common to the region. A comparison of the two materials did not substantiate this view, and it would seem that such must be in some way connected with the meteoric phenomena, though it was not possible to correlate them absolutely with the nickeliferous granules. Hole No. 20 yielded a quantity of dark brownish particles from 1 to 3 mm. in diameter, which in thin sections showed a ground of radiating, imperfectly differentiated crystals of a gray color and undetermined

[1] Analyses by Mr. Tassin of the metallic particles, freed from siliceous matter as much as possible by hand picking and the magnet, yielded: SiO_2, 12.75 per cent; Fe, 68.17 per cent; NiCo, 12.14 per cent; P, 5.07 per cent; total, 98.93 per cent. The SiO_2 was in form of free quartz.

nature, enclosing some amorphous matter, numerous shattered and more or less altered quartz granules, and an occasional black, highly lustrous particle, assumed from its association to be chromite. This material gave a strong qualitative reaction for nickel.

The underlying red sandstone, met with at depths of approximately 800 feet from the surface and referred to as forming the "floor" of the crater, was brought up from time to time in the form of short sections of drill cores. These were examined in thin sections, and in no instance did they show any signs whatever of the shattering, fusion, or metamorphism so characteristic of the overlying white sandstone[1] (fig. 127).

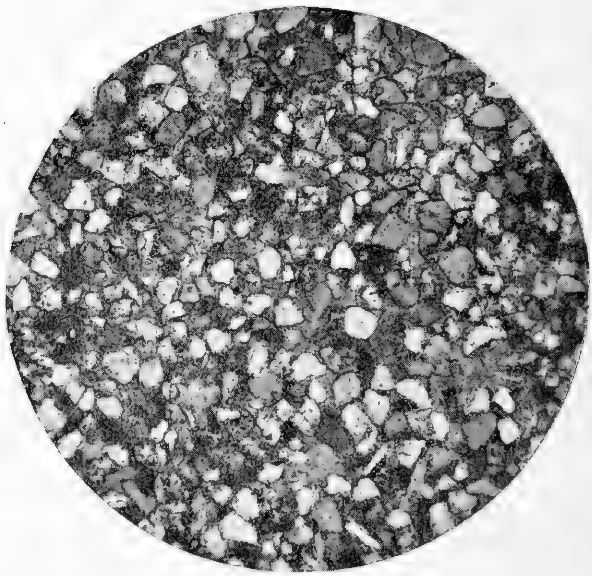
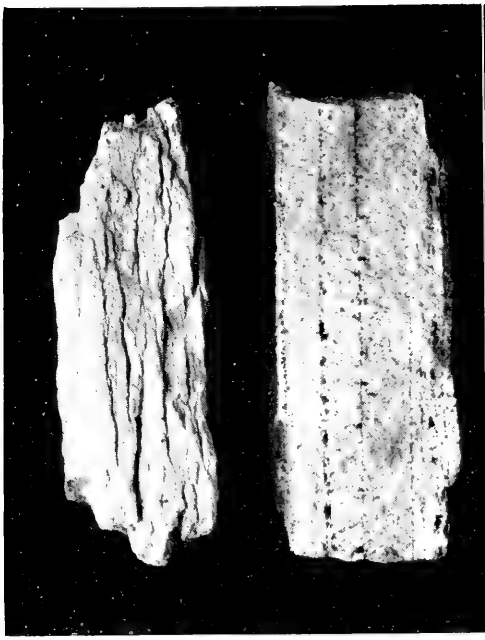


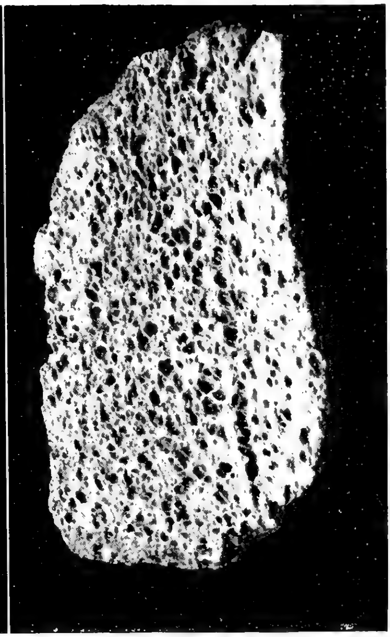
FIG. 127.—Showing Microstructure and Unaltered Character of Sandstone Underlying Crater.

V. THE METEORIC IRONS

History of Early Finds.—The first public announcement of the finding of meteoric irons near Canyon Diablo was that made by Mr. A. E. Foote at the Washington meeting of the American Association for the Advancement of Science, August 20, 1891. In this paper,

[1] Cores were not available from as many holes as could have been desired. Those examined were of sandstone of a distinctly red hue and from holes Nos. 4, 6, 7, and 8 (see diagram, fig. 125), No. 6 being from a depth of 1,065 feet and No. 8 from 1,080 feet below the crater bottom.





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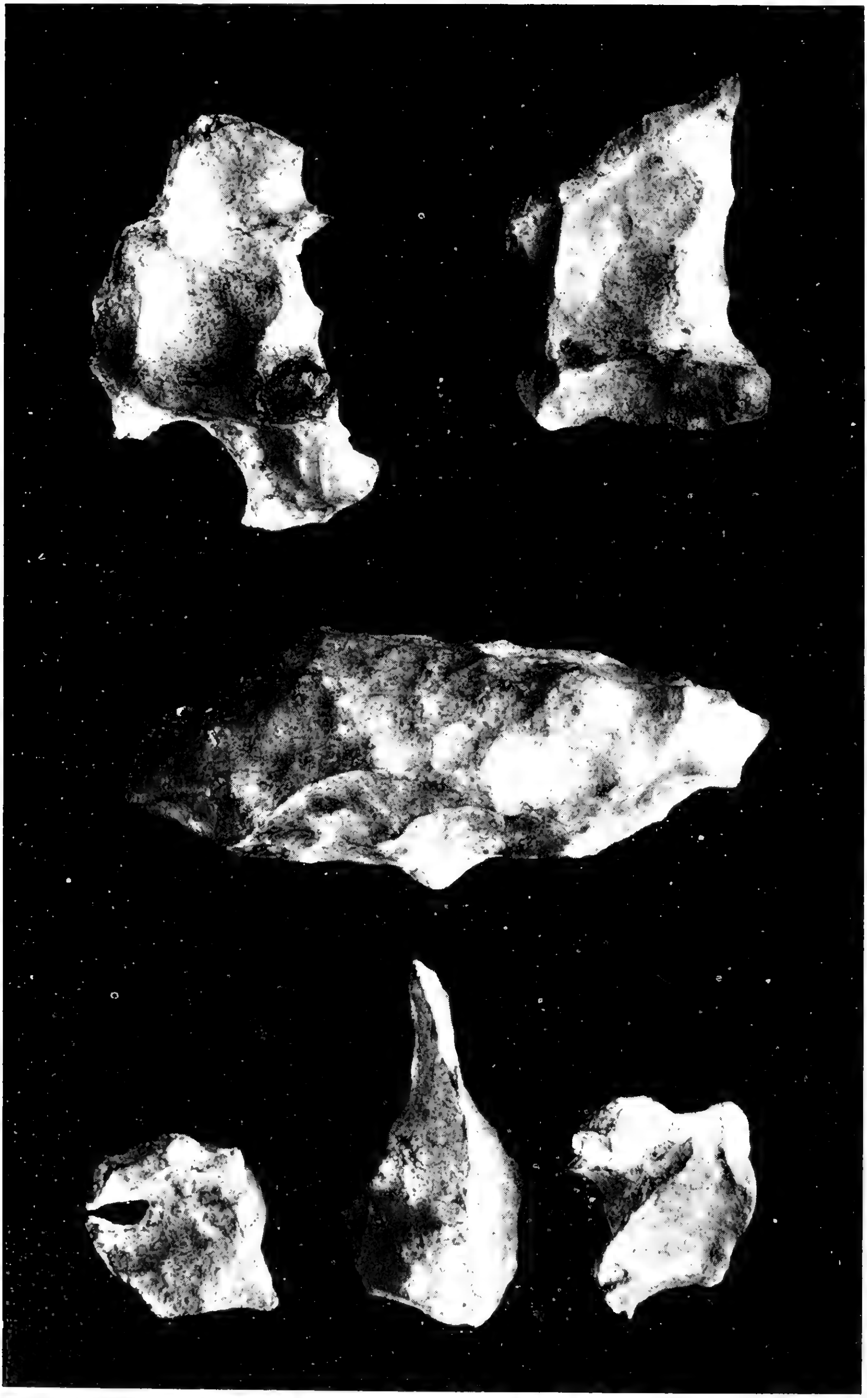
ALTERED SANDSTONE FROM SHAFTS INSIDE OF CRATER

(See explanation of plates.)



TYPICAL FORMS OF CANYON METEORIC IRONS

which was published in both the proceedings of the Association and the American Journal of Science,[1] Mr. Foote stated that, at that time, nearly all of the small fragments had been found at a point about 10 miles southeast from Canyon Diablo and near the base of a circular elevation locally known as Crater Mountain, but the origin of which he was unable to explain. Mr. Foote's interest lay largely with the meteoric irons, of which he reported that over 137 fragments had been found, the largest of which weighed 201 pounds (91.171 kilograms). He also noted the occurrence at the base of the crater of many oxidized and sulphureted (*sic*) fragments, some of which showed a greenish stain, resulting probably from the oxidation of the nickel. This oxidized material he regarded as identical with an incrustation which covered the surface of some of the iron or filled the pits in the same. With the aid of analyses by Dr. G. A. König, Foote was able to announce the iron to contain (1) small diamonds, both black and white; (2) carbon in the form of a pulverulent iron carbide, the precise nature of which was not made out; (3) sulphur; (4) phosphorus; (5) nickel; (6) cobalt, and (7) silicon.

Naturally this announcement was received with great interest by members of the Association and others—an interest which was kept up for a long period by the rapidly accumulating evidence and final proof of the presence of minute diamond crystals in the iron, and also by the large number of irons and their oxidation products subsequently found.

The exact number of independent masses of the iron that the locality has yielded and their aggregate weight can never be known, owing to the many comparatively small pieces carried away by visitors or purchased from Mr. Voltz, an Indian trader in the neighborhood who has made it a matter of business to search for them, even hiring men and boys and plowing the ground over certain areas. An estimate of the total weight, which can be considered little more than a guess, is 20 tons, while the numbers run up into thousands, weighing from not over a gram to 460 kilograms (1,013 pounds) each, the latter weight being that of the large specimen in the Field Museum at Chicago. The irons are characterized by deep concave and convex surfaces and peculiar pittings or holes, an inch or more in diameter, which sometimes extend through the mass (see pl. LXXIII), and are commonly regarded as due to the oxidation and crumbling away of nodules of iron sulphide (troilite). Each iron seems to form a complete individual, with no visible signs

[1] Vol. 42, 1891, pp. 413–417.

of rupture from a parent mass, nor fusion and flow structure from its flight through the atmosphere. The probable significance of this is mentioned later.

Distribution of the Irons.—These irons, it should be stated, have been found scattered without determinable order over an area of several square miles about the crater. It is unfortunate also that the even approximately exact distribution of the larger masses can not be given, the collecting having been done largely by irresponsible parties, who were interested merely from a commercial standpoint.

Mr. Gilbert in 1896[1] stated that "no iron has been found within the crater, but a great number of fragments were obtained from the outer slopes, where they rested on the mantle of loose blocks. Many others were obtained from the plain within the region of scattered débris, and others, though a smaller number, from the outer plain. One large piece was discovered 8 miles east of the crater, or almost twice as distant as any fragments of the ejected limestone. Another was long ago discovered 20 miles to the southward, but what became of it is not known and it has not been definitely identified as a member of the same meteoric shower."

Mr. Tilghman, writing ten years later (1906), and after the work of development had been some time under way, says: "In the last two years the author and the men in his and Mr. Barringer's employ have picked up more than 2,000 such irons, ranging in weight from 200 pounds down to a small fraction of an ounce, and have platted the position of these finds upon a chart, which shows plainly that the principal locality for such finds is in the shape of a crescent surrounding the hole and strictly concentric therewith, and embracing its edges from the northwest to the east, and having its line of greatest density about midway between these two points."

Mr. Barringer, in the same publication, states that four irons, weighing from 3 to 4 pounds each, have been found on the interior of the crater, and "so far as I know, these are the only iron specimens which have been found inside the crater."

It is obvious, from a consideration of these statements, that nothing regarding the direction of the flight of the meteors can be gained from a study of their present distribution, it being a well-known fact that in all recorded showers the larger members have been carried the farthest, so that a gradual assortment in sizes takes place along the line of flight.[2]

The evidence of the crater walls, however, seems to at least sug-

[1] Op. cit., p. 16.

[2] It may be well to state that a 960-pound mass in the National Museum, purchased in 1893 from parties at Winslow, Arizona, was reported as having

gest that if due to impact of a bolide, the same came from a direction a little north of west, though at a very high angle, perhaps not less than 70°. Proof of this lies in the greater amount of shattering and upturning shown by the beds in the eastern wall of the crater (see typical east and west section, station 18), and in the greater distance to which débris has been thrown to the east as compared with that in any other direction.

These irons it should be stated, have all been found near, and in many cases actually on, the surface. At most they have been buried scarcely enough to cover, and in the case of most of those found have been in part uncovered by wind or water erosion. It is the writer's opinion, based upon an examination on the ground, that a very large proportion of them were buried to a slight depth, and are being gradually brought to the surface through the action of the wind blowing away the finer and lighter material from around them, or, on the slopes of the crater in particular, by the rush of water from the spasmodic rains. As found, but a small portion of an iron projects above the surface, and, being of a rusty brown gray color, is easily passed over by any one not experienced in hunting them. When embedded they are covered with but a slight coating of oxide, though usually more or less incrusted, particularly on the lower sides and edges, with carbonate of lime. A cut section of what may be called the typical iron is shown in plate LXXIV. It is characterized, as long since noted by Brezina,[1] by a coarsely lamellar structure composed of broad plates of kamacite with very little tænite and occasional nodules or troilite.

Chemical and Mineralogical Properties.—The chemical, physical, and mineralogical properties of the iron have been discussed by several workers, the chief interest naturally centering around the occurrence of the diamond. Foote in his paper announced that the iron contained (1) small diamonds, both black and white; (2) carbon in the form of pulverulent iron carbide, the precise nature of which was not made out; (3) sulphur; (4) phosphorus; (5) nickel; (6) cobalt, and (7) silicon. Huntington, the year following, described somewhat briefly, and in 1894[2] more in detail, the methods and re-

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been found in a canyon at Peach Springs. This statement I have not been able to substantiate, not being able to get into communication with the parties mentioned. Peach Springs is at least 100 miles west of the crater. Knowing what he does of the conditions existing at the time the iron was purchased, the writer feels justified in believing the source as given to be erroneous, and that the iron actually came from near the crater.

[1] Wien Sammlung, 1895, p. 288.

[2] Proc. American Acad. Boston, vol. 29, 1894, p. 209.

sults obtained by him in isolating small colorless octahedral diamonds and also yellow and black particles having the hardness of diamond. Other papers by Mallard,[1] Daubree,[2] Friedel,[3] and Moissan[4] were all confirmatory and corroborative of Huntington's results.

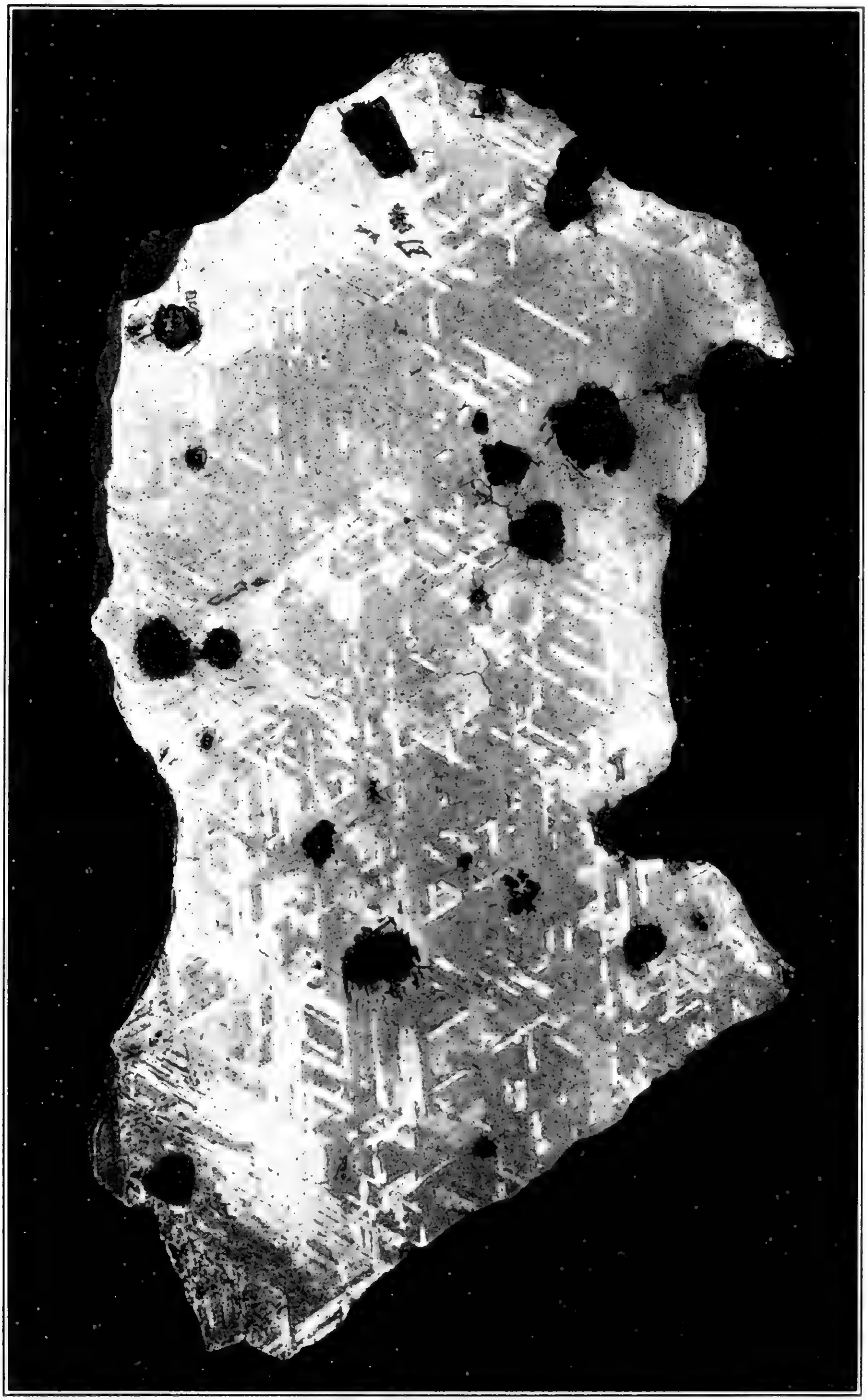
Brezina,[5] in 1893, noted the finding of the iron (which he wrongly located as in *New Mexico*), and called attention to its crystallographic structure and occurrence about the crater—a fact which raised in his mind the question of the latter being incidental or consequent. In 1895[6] he returned to the subject, described the external appearance of the iron as found, and noted that natural etched surfaces showed the iron to be composed principally of kamacite plates without appreciable tænite. He noted also the presence of cohenite and troilite-graphite nodules, and that the tænite residues lying parallel with the octahedral faces were as strongly marked as in the freshly etched iron.

Derby, in 1895,[7] published the results of investigations upon the chemical and mineralogical nature of the iron, and reported the occurrence of tænite, schreibersite (and rhabdite), cohenite, diamonds (probably), and amorphous carbon, with traces of chromium and a relatively high percentage of copper. Analyses of the tænite and schreibersite were given. The form of the irons (see pl. LXXIII), he suggested might be due to their having been "small irregular metallic masses scattered through the stone matrix of a mesosiderite," and he ventured the hypothesis that the mass on arriving in our atmosphere, as a mesosiderite, contained unusually large metallic nodules that became separated by the explosion attending the fall, and probably also by consequent decay and disaggregation of the stony matrix.

Cohen, in 1900 (Meteoreisen Studien, XI), made similar examinations with results confirmatory of Derby.

Moissan, in 1904,[8] published important chemical contributions, giving analyses of the iron and the included troilite nodules, and announced the finding of carbon in three forms—amorphous, as graphite, and the diamond. He also announced the finding in his insoluble residues from the iron of a green mineral in the form of

[1] Comptes Rendus, vol. 114, 1892, p. 812.
[2] *Ibid.*, vol. 114, 1892, p. 812, and vol. 116, 1893, p. 345.
[3] *Ibid.*, vol. 115, 1892, p. 1037, and 116, 1893, p. 290.
[4] *Ibid.*, vol. 116, 1893, p. 288.
[5] Ueber Neue Meteoreisen, 1893.
[6] Wien Sammlung, 1895, p. 288.
[7] American Jour. Sci., vol. 49, 1895, p. 101.
[8] Comptes Rendus, vol. 139, 1904, p. 773.



ETCHED SECTION OF CANYON DIABLO IRON

hexagonal plates which analysis showed to be a silicide of carbon. Kunz later proposed that this mineral be named *Moissanite,* in honor of its discoverer.

The complete mineralogical composition of the meteorite as given by these various writers, including Mr. Tassin, is, then, as follows:

Nickel iron:
- (1) Kamacite.
- (2) Plessite.
- (3) Tænite.

Phosphide of iron:
- (1) Schreibersite.
- (2) Rhabdite.
- (3) A black phosphide, unidentified.

Carbide of iron:
- (1) Cohenite.
- (2) Graphitic iron (?)

Sulphide of iron:
- (1) Troilite.

Chloride of iron:
- (1) Lawrencite.

Silicide of carbon:
- (1) Moissanite (Moissan).

Carbon:
- (1) Diamonds, colorless, yellow and black.
- (2) Cliftonite.
- (3) Amorphous.
- (4) Graphite.

Silicon (Tassin).
Platinum (Mallett).
Copper (Derby).
Olivine (very rare) (Tassin).
Chromite (Tassin).
Fayalite (?) (Tassin).
Daubreelite (Foote and Derby).

Of the several partial and complete analyses of the iron that have been published, the following are selected, No. 1 being by Moissan, No. 2 by Booth, Garrett, and Blair, and Nos. 3 and 4 by Wirt Tassin, No. 4 being that of a shale-ball iron next to be described:

Constituents.	1.	2.	3.	4.
Fe	95.370	91.396	93.510	94.030
Ni	3.945	7.940	5.600	5.320
Co	....	....	0.044	0.020
Cu	....	....	Trace.	0.010
P	0.144	0.179	0.156	0.235
S	Trace.	0.004	0.010	0.005
C	....	0.417	0.512	0.121
Si	Trace.	0.047	0.050	0.020
Cl	....	....	0.000	0.120
Insol.	0.260	....	....	....
Total	99.719	99.983	99.882	99.881

VI. The Iron Shale and Shale Balls

Occurrence, Composition, and Origin.—Scattered over the surface of the plain, and practically coextensive with the iron, are abundant fragments and nodules of brown iron oxide, sometimes stained greenish from the presence of a nickel hydroxide. These, as a rule, have a somewhat shaly or platy structure, the plates sometimes slightly

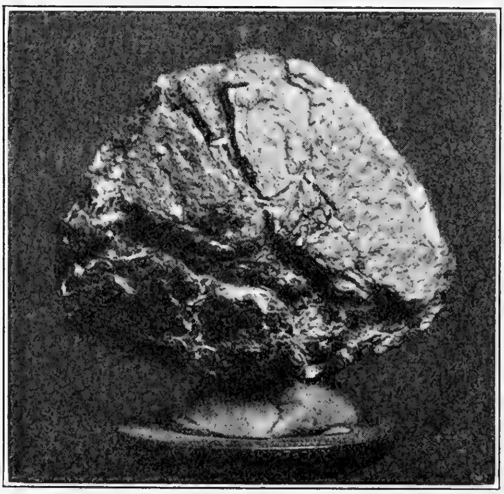


Fig. 128.

curved, or again, and more rarely, are in the form of flattened ovals sometimes pear-shaped, and invariably deeply cracked and fissured (fig. 128). These shale fragments were noted by Foote in 1891 and their probable connection with the iron suggested. The oval "shale balls" were, however, first noted by Mr. Barringer. That both have the same origin would seem most probable. Foote described the material as "identical in appearance with an incrustation which covered the surface of some of the irons or filled the pittings in the same." Its occurrence in such large quantities he though indicated that an extraordinarily large mass, of probably 500 or 600 pounds weight (!), had become oxidized while passing through the air, and so weakened that it burst into pieces not long before reaching the earth. It is needless to state that Foote's estimate of the size of the meteoric mass was at least conservative.

Derby, writing in 1895, advocated the idea of the origin of the schistose masses by secondary alteration—*i. e.*, terrestrial weathering. This view was generally accepted, but the question was opened up again through the publication of Messrs. Barringer and Tilghman, the first named, after noting the distribution of the material as coextensive with the iron, stating his belief that it was produced by the heat generated from friction while the meteor passed through the earth's atmosphere. And again (p. 877): "We have assumed that these small particles (*i. e.*, of shale in form of fragments and spherules) once constituted a portion of the great luminous tail of the meteoric body."

Mr. Tilghman puts the matter a little more definitely in stating that it "is fused and massive and at the same time stratified and laminated and in general appearance different from any terrestrial magnetite known, and closely resembles what would be thought, *a priori*, to be the appearance of such a product of iron melted and burned on the surface of a great meteorite in its passage through the air."

In explanation of the term "magnetite" as used by Mr. Tilghman, it may be said that the particles are almost invariably somewhat magnetic—more so, in fact, according to Mr. Barringer, than are the irons themselves. This has led to the assumption that they are composed, in part at least, of iron in the form of magnetite. Nichol's analyses, as given by Farrington,[1] showed the material to consist mainly of iron in the form of FeO and Fe_2O_3 with smaller amounts of the other constituents characteristic of the unaltered material. From these analyses Farrington made the calculation of the constitution of the shale as below:

Limonite	52.99
Magnetite	42.39
Schreibersite	0.64
Graphite	0.15

[1] American Journal Science, vol. XXII, 1906, p. 303.

Lawrencite	0.14
Aragonite	0.80
Andradite	2.45
Quartz	0.21
	99.77

The work of Tassin, next to be referred to, throws doubt upon these conclusions, it being claimed that the magnetic character of the shale is due to the minute particles of unaltered schreibersite, already noted. The origin attributed to this oxide, either in the form of fragments or the oval and pear-shaped masses, by the writer is given below in the consideration of—

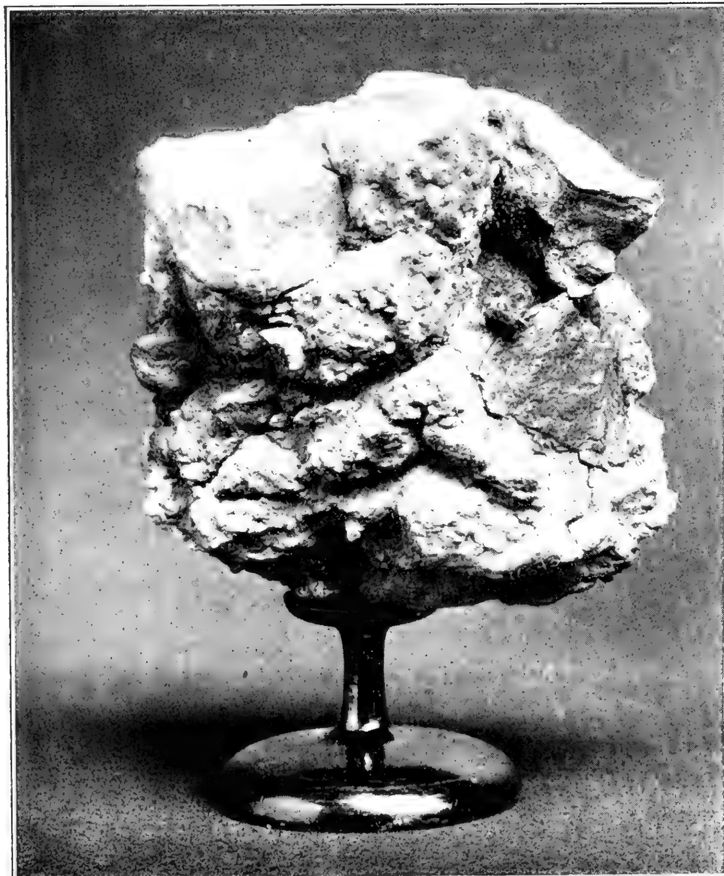
The Shale Balls.—In the publication by Mr. Barringer reference is made to the finding, principally in pits and open trenches on the north side of the crater rim, of numerous nodular masses of more or less oxidized meteoric material, to which the name "shale balls" was given. These were studied by Merrill and Tassin,[1] the conclusion reached being that such represented chloride-sulphide rich masses of the iron which, through the protective action of the earth, had escaped complete oxidation and afforded an opportunity for the observation of the transition stages (pl. LXXIV). In short, that the iron shale was, as surmised by Derby and others, but a product of natural oxidation, after reaching the ground, of a peculiarly susceptible phase of the iron. Such an origin seemed absolutely proven in cases where a cross-section showed the plates of unoxidized iron phosphide still retaining their original orientation, although the nickel iron had all gone over to the condition of limonite. In many of the smaller blebs no such transition could be observed, and their like origin is assumed from analogy only. It is to be noted that the contention of Messrs. Barringer and Tilghman apparently finds support from Lockyer.[2]

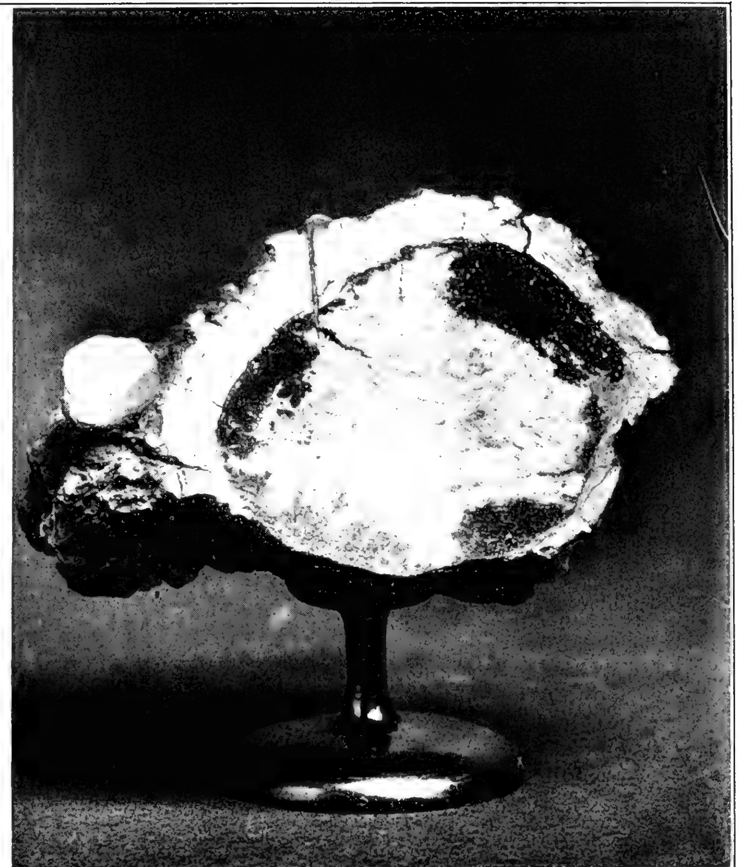
The relationship of the shale-ball irons to the typical irons is expressed as follows:

We have therefore come to the conception of a large heterogeneous mass of nickel-iron with segregation masses rich in chlorides, phosphides, and sulphides. Such would naturally rupture most readily along the line of contact with the more homogeneous portions, and, moreover, the results of at-

[1] Smith. Misc. Collections (Quarterly Issue), vol. 50, 1907, p. 203.

[2] Meteoric Hypothesis, p. 69. He says: "It is natural to suppose that meteors in their passage through the air break into fragments; that incandescent particles of their constituents, including nickel-iron, manganese, and the various silicates, are thrown off, and that these, or the products of their combustion, eventually fall to the surface as almost impalpable dust, among which must be magnetic oxides of iron more or less completely fused."





1 SHALE-BALL IRONS FROM TRENCHES ON NORTH RIM OF CRATER 2

mospheric frictional heat would ignite and burn away the sulphide portions. Even where the heterogeneous masses of considerable size fall to the earth, it is possible that these susceptible portions would oxidize and wholly disappear, leaving the more refractory to be found later. This would account for the almost constant association of shale and irons of the type shown in plate LXXIII at various points out on the plain.

The occurrence of the still incompletely oxidized forms—shale balls—as described, is due to the protective action of the dry soil in a region of great aridity, the annual precipitation, as recorded by the Weather Bureau, being but about 8 inches. It has been shown that under such conditions soils rarely or never become saturated with moisture for more than a few inches below the surface, and that this moisture is brought back by capillarity and evaporated rather than drained off at lower levels, as in more humid regions. An iron thus buried, even though rich in chloride and sulphide, would endure for a long period.

The connection of the shale balls with the embedding material is noted on page 465.

Analyses of the new variety of the iron and of the shale are given on page 484; those of the three iron phosphides[1] and of cohenite have not been reproduced.

VII. Origin of the Crater

Opinions for and against the Meteoric Hypothesis.—The origin of the crater has been discussed or suggested from time to time by various authors. So far as I am aware or as shown by the literature, the first hypothesis that need be taken seriously is that put forward by Mr. W. D. Johnson,[2] who concluded from a somewhat superficial study that "in some way, probably by volcanic heat, a body of steam was produced at a depth of some hundreds or thousands of feet, and the explosion of this steam produced the crater." In this view the occurrence of the meteoric irons was of course merely a coincidence.

Mr. Gilbert, at whose request Mr. Johnson had made the preliminary studies, acknowledged himself as not quite satisfied with these conclusions, and in the summer of 1892 undertook, in coöperation with the late Marcus Baker, a more detailed study of the region. In connection with these studies there was prepared by Mr. Baker the topographic map, a copy of which is here reproduced.[3] An excellent series of photographs were also taken, a part of which is here utilized,

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[1] Derby thought to find three forms in the typical iron also.

[2] See Gilbert, op. cit., p. 9.

[3] For a redrawing of this map from a reduced photographic copy I am indebted to the U. S. Geological Survey.

and several petrographic and chemical analyses made, all of which have been put at my disposal. Mr. Gilbert, in the systematic and conservative manner for which he is noted, considered the problem from various standpoints, and particularly with reference to the theories of its having been formed by the (1) "collision and penetration of a stellar body"—*i. e.*, by a meteorite, and (2) by steam explosion. In the light of the evidence then available, Mr. Gilbert did not feel justified in adopting the meteoric hypothesis, and, as the only available alternative, was forced to adopt the second mentioned above, though those who know Mr. Gilbert thought to read in his report a strong leaning toward the first mentioned, abandoned only because not borne out, so far as he could see, by the facts. His failure to recognize the tendency of Mr. Diller's studies is not so strange when it is recalled that but a few fragments of the fused material had then been found scattered over the plain, and with no certain connection with the crater. It was not until more was discovered in the work of prospecting, at a depth of several hundred feet below the surface, that its full significance was realized.

Though a matter of frequent discussion among those more or less conversant with the facts, nothing of value relating to the subject appeared until 1905, when Messrs. D. M. Barringer and B. C. Tilghman presented their results before the Philadelphia Academy of Science.[1] Mr. Barringer described the crater and the character of the ejectamenta in great detail, laying particular stress upon the "silica," or pulverized sand grains (rock-flour), derived from the sandstone. He reviewed the work of Gilbert and thought to prove (p. 885): (1) that a great meteor, wholly or in part metallic, fell to the earth at this locality, and (2) that the crater was made by and at the instant of time of the fall of this meteor. Mr. Tilghman dis-

[1] Coon Mountain and Its Crater, by Daniel Morean Barringer; Coon Butte, Arizona, by Benjamin Chew Tilghman. Proc. Acad. Nat. Science of Phila., December, 1905. Issued March 1, 1906, pp. 861–914. It may be well to state in this connection that Mr. Barringer is a well-known and successful mining engineer and joint author with J. S. Adams of a work on Laws of Mines and Mining in the United States. Mr. Tilghman, on the other hand, is a high authority on velocity and impact of projectiles. These gentlemen, basing their preliminary operations upon reports of Mr. S. J. Holsinger, took the necessary steps to locate the "mountain" under the U. S. mining and land laws, and proceeded to bore and sink shafts in and about the crater, with a view of locating the fallen body, which they believed to lie there, desiring to exploit it as a source of nickel, iron, and platinum. The conclusions regarding the origin of the crater, now arrived at, are based, so far as the present writer is concerned, almost wholly upon results obtained in these mining operations.

cussed the physical aspects of the crater with reference to its similarity to those produced by projectiles, and also discussed Mr. Gilbert's hypothesis, the distribution of the iron and magnetic oxide about the hole, the crater rim and interior, and the disintegrated sandstone. His conclusions were that (p. 910): (1) at this locality there is a great hole or crater corresponding in all respects except size with impact craters formed by projectiles of considerable size moving at considerable velocities; (2) that in and about the hole and to a distance of over 1,400 feet below the present surface of the plain "every indication of either volcanic or hot-spring action was positively absent;" (3) that all signs which might be expected of the impact of a great projectile were present; (4 and 5) that the meteoric material scattered about the hole and over the plain was deposited at the same instant of time at which the hole was made; (6) that in and around the hole is a quantity of material such as could be produced only by a violent blow; and, finally, that all the attendant minor phenomena observed can be explained upon the theory of the impact of a great projectile and none can be satisfactorily explained upon any other theory. In view of these facts, Mr. Tilghman felt himself justified in announcing that the formation of the crater "is due to the impact of a meteor of enormous and hitherto-unprecedented size."

With these conclusions the present writer freely confesses he was not at first inclined to agree. In several minor matters, as that relating to the origin of the iron shale and shale balls, he is still at variance with them; but after going over the ground with both gentlemen, noting the results of the borings, and restudying the problem from all standpoints, he gives the following summary of his conclusions:

VIII. Summary

Consideration of Evidence.—So far as shape is concerned, the crater could have been formed equally well by blow-out or impact.

The character of a portion of the ejected material points, however, strongly to an origin by impact. It is difficult, if not impossible, to conceive of the smashing and metamorphism of the sandstone on any other ground. The sand grains are crushed in a manner that could be brought about only by some sudden shock, such as might possibly be imparted by an explosion of dynamite, but certainly not by steam. The secondary foliation at an angle with the bedding and the condition of molecular strain of the altered quartz indicates pressure, while the fused quartz indicates great heat. The latter might be due either to impact or to vulcanism. The association of the fused pumiceous masses with the smashed material, together with the transition of one form into another, is such as to suggest a common origin for both.

The slightly disturbed and unchanged condition of the deeper-lying sandstone seems to prove the superficial character of the phenomena. Where disturbed, the beds apparently dip downward, as though forced out of position by some power acting from above. This apparently prohibits the consideration of a deep-seated cause. There being nothing in the beds themselves to bring about such results, one is forced to the consideration of an extraneous source; and, if extraneous, I can conceive of but two—the electric and meteoric. Of these, only the latter seems worthy of serious consideration.

Velocity of Meteorites and Possible Depth of Penetration.—Unfortunately we have little to guide us in estimating the speed at which a meteorite reaches the earth and its consequent power of penetration. The velocities as given by various observers vary between 2 and 45 miles per second. These last, however, are the initial velocities, the velocities possessed by the meteors on entering our atmosphere and while still at considerable altitudes—in some instances 50 or 60 miles—and which become very materially reduced by atmospheric friction long before reaching the earth. Indeed, from the calculations of Schiaparelli and others, it is commonly assumed that a meteorite reaches the surface at the speed of an ordinary falling body. A. Herschell, as quoted by Flight,[1] calculated the velocity of the Yorkshire (England) meteorite at the time it reached the ground as but 412 feet a second. The Guernsey, Ohio, meteorite was estimated by Prof. E. W. Evans[2] to have reached the earth while traveling at a speed of 3 or 4 miles a second; that of Weston, Connecticut, while at a height of some 18 miles, was estimated by Professor Bowditch[3] to have a velocity of 3 miles per second. Newton[4] calculated the speed of the fire-balls which passed over the Ohio and Mississippi Valley in August, 1860, as 30 to 35 miles per second, and stated[5] that the Stannern, Moravia, stone came into our atmosphere with a velocity of 45 miles per second. These higher velocities are

[1] A Chapter on the History of Meteorites, p. 219.

[2] Amer. Jour. Science, vol. 33, 1861, p. 30.

[3] Mem. Amer. Acad. Arts and Sci., vol. 3, 1815, p. 213.

[4] Amer. Jour. Sci., vol. 33, 1862, p. 338.

[5] Amer. Jour. Sci., vol. 36, 1888, p. 11.

doubtless those of bodies pursuing a retrograde course about the sun.

The evidence afforded by actual falls and impacts is extremely contradictory. Thus Nordenskiold[1] states that, in the case of the Hessle fall, stones so friable as to be readily broken if simply thrown against a hard surface were not broken or even scarred on striking the frozen ground. Stones weighing several pounds which struck on ice a few inches in thickness rebounded without breaking the ice or being themselves broken. The 70-pound stone that fell at Allegan, Michigan, in 1899 penetrated the sandy soil to a depth of about 18 inches and was itself considerably shattered. Like that of Hessle, this was an unusually friable stone. It is evident that its speed did not exceed that of a projectile from an old-time piece of heavy ordnance. The 260-pound stone that fell at Ensisheim, Germany, in 1492 is reported to have buried itself to a depth of 5 feet.

The greatest depth of penetration of a meteoric stone which has come under the writer's observation is that of Knyahinya, Hungary, as described by Haidinger.[2] In this instance a 660-pound stone, striking the ground at an angle of some 27° from the vertical, penetrated to a depth of eleven feet. The hole was nearly circular in outline, and fragments from the interior were thrown back and scattered to a distance of some 180 feet (dreiszig Klafter). The stone was found broken in three pieces and the earth beneath it compacted to stony hardness, but nothing in the description as given indicates that any traces of metamorphism, either in the ground or mass of the stone, had taken place. On the other hand, still heavier masses have been found under such conditions as to lead one to infer they scarcely buried themselves.

Peary's giant Cape York iron, weighing 37½ tons, was found only partially covered; but, as it lay on a bed of gneissic boulders, this is not strange. It should be remarked, however, that an examination of the iron reveals no such abrasions of surface as might be expected had it fallen with a speed of miles per second, or, indeed, any abrasions whatever that can be ascribed to such a cause. It is, of course, possible that this fall took place when the ground was

[1] Kongl. Svenska Vetenskaps-Akademiens Handlingar, B. 8, No. 9, 1870.

[2] Sitz. d. k. Akad. d. Wiss, II Abth. B. LIV, 1866. This occurrence illustrates on a small scale so perfectly what is supposed to have happened at the meteor crater that I feel justified in giving here a photographic reproduction (fig. 129) of page 20 of Haidinger's paper. The description, beginning with the seventh line from the top, refers to figures 5 and 6.

deeply covered with ice and snow, and its speed was thus checked before coming in contact with the stony matter.[1]

The Williamette iron, weighing 15.6 tons, seemingly lay without question as it originally fell, and in a region of no appreciable erosion—rather, one of organic deposition, for it was found lying in a primeval forest; yet the mass was scarcely buried, a small projecting portion leading to its discovery.

20 v. Haidinger.

einer Wiese, genannt Cserne Mlaki, auf dem Sztusicsaer Hotter befand, in der Gegend *B* auf Fig. 1 und 2.

Auf der Ansicht Fig. 2 ist diese Wiese von dem vorliegenden Javornik-Berg bedeckt, und daher nicht sichtbar. Sie schließt sich an den jenseitigen Bergrücken rechts an den Sztyinszka-Felsen in dem weiteren Verlaufe desselben an.

Fig. 5

Es ließ sich wohl vermuthen, daß diese Grube durch einen größeren Meteorstein verursacht worden sei. „Von Herrn Waldbereiter ausgesendet, „sagt Herr Pukáts," machte ich mich eines Tages um 3 Uhr Früh auf, um den Stein zu heben. Beim Anlangen auf der Wiese erblickte ich ein etwa 4 Fuß breites und 4½ Fuß tiefes Loch mit aufgeworfenen, umgestülpten Rändern, wie bei einem durch einen elektrischen Funken durchgeschlagenen Kartenblatte. Rasenstücke lagen bis dreißig Klafter vom Loch entfernt umhergeschleudert. Ohne Zweifel lag dort ein Stein, aber wie tief? Mit nur sehr wenig Werkzeugen suchte ich zuerst durch Einschlagen eines Pflockes die Tiefe zu ergründen. Nach dem ersten Einschlagen ließ ich um den Pflock herum die Erde weggraben und denselben sodann tiefer einschlagen, was auch in dem zerbröckelten Karpathen-Sandsteingebilde nicht schwer war. Aber immer noch kein fester Grund. Ein solcher wurde erst erreicht als ich den Pflock in der Richtung γ einschlagen ließ. Erst jetzt stießen wir auf etwas festes, aber ein abgebrochenes Stück (α), welches ich für einen Theil des Ganzen ansprach, und daher weiter graben ließ, bis wir den großen Stein β gefunden hatten. Er lag über 11 Fuß tief in dem Boden, und war in zwei Theile zerspalten. Da jeder Theil mehr als dritthalb Centner wiegt, so gelang es nur mit großer Anstrengung und mit eingelegten Treppenvorrichtungen, da nur Ein Mann mit voller Gewalt angreifen konnte," und endlich Herr Pukáts selbst Hand anlegte „dieselben herauszuwälzen. Der Grund, auf dem der Stein lag, war steinhart zusammengedrückt."

Fig. 6.

FIG. 129.—Page from von Haidinger's description of Knyahinya meteorite. Shows formation of small crater. See footnote, p. 491.

The Bacubirito iron, weighing at a rough estimate 20 tons, lay in a soft soil, with its surface but little below the general surface of the field around it.

[1] Mr. Tilghman informs me that lead bullets from a modern rifle may be completely checked in traversing a few feet of light snow, and this, too, without the slightest appreciable deformation or surface abrasion.

These illustrations are sufficient to show the contradictory nature of the evidence. Such contradictions can be partially explained by taking into consideration the varying angles at which the meteorites come in contact with the earth and the direction of their flight. One falling from a great height almost vertically would naturally have a greater power of penetration than one coming at a low angle. More important yet is the direction of flight of the meteor with reference to the earth. If following the earth in its course about the sun, the apparent speed would be but differential. Thus a meteorite with a velocity of 25 miles per second overtaking the earth traveling at the rate of 19 miles per second would enter our atmosphere with an initial speed of but 6 miles per second, and this through atmospheric friction would be so far reduced as to give the lower figures above mentioned, or the speed of an ordinary falling body. In the case of a meteorite pursuing a retrograde course, conditions are greatly exaggerated. With a velocity of 25 miles a second, it meets the earth traveling in the opposite direction at the rate of 19 miles per second, and hence enters our atmosphere with an initial velocity of 44 miles per second. Here, as before, the retarding effect of the earth's air cushion must be considered. With such a velocity, friction must be tremendous, and even in the few seconds occupied in its transit large quantities of its material must be dissipated. That such is the case we have unquestionable proof in the luminous trains of meteors, and H. E. Wimperis[1] has calculated that "no iron meteor the original weight of which was less than 10 to 20 pounds reaches the earth's surface," being entirely consumed in its passage.

Schiaparelli, as quoted by Fletcher,[2] has shown that if a ball 8 inches in diameter and of 32½ pounds in weight enters our atmosphere with a velocity of 44¾ miles per second, its velocity on arriving at a point where the barometric pressure is still but 1/760 of that at the earth's surface will have been already reduced to 3½ miles a second—figures which correspond fairly well with the estimates made on the flight of the Weston and Guernsey stones.

Dr. R. S. Woodward, as quoted by Mr. Gilbert,[3] has calculated that a body reaching the surface of the moon with a velocity of 1½

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[1] Nature, vol. 71, 1904–'05, p. 82. The writer well remarks: "I am aware that the whole structure of the investigation (*i. e.*, his calculations) rests on the evil principle of extrapolation, but until man is capable of experimenting with velocities of 10 or 20 miles per second, and surviving thereafter to record his results, no other manner of investigation seems possible."

[2] Introduction to the Study of Meteorites, 1896, p. 26.

[3] The Moon's Face, Bull. Philosophical Soc. of Washington, vol. XII, 1893, p. 258.

miles per second would, if all the equivalent energy were converted into heat and all stored in the mass of the falling body, suffice to raise its temperature, supposing it to consist of ordinary volcanic rock, through 3,500 degrees of the Fahrenheit scale, or within 400 degrees of the temperature necessary to fuse quartz. How far these results are applicable to the case in hand is problematical, since, as Huxley has remarked, "what one gets out of the mathematical mill will depend upon what is put in it," and in this particular case both the size and velocity of the body must be assumed, and to a certain extent its composition as well. We have, however, unquestionable proof of a force of impact sufficient to crush a mass of limestone 300 feet in thickness, which has been shown by tests on cubes of but one inch in diameter to possess an average crushing strength of 12,595 pounds per square inch of surface, and of sandstone 500 feet in thickness capable of withstanding a pressure of 6,350 pounds;[1] and this, too, with a production of heat equivalent to the 3,900°, or fusing point of quartz, above noted. It is well-nigh impossible, however, that a force so great, and applied, as is apparent, in an instant of time, should not have been productive of an amount of heat so vastly greater than 3,900° that its expression in figures would be utterly meaningless and incomprehensible, and in the writer's mind the greatest difficulty in accepting the meteoric hypothesis lies in the absence of sufficient evidences of such extreme temperatures. There are no volatilization products and but slight evidence of slags among the products thus far brought to light. Only the fused quartz remains as a tangible proof.

The formation of the crater rim and the presence of the enormous blocks of stone therein may, as above noted, be explained on either the blow-out or impact hypothesis. The presence in this rim of blocks of the altered sandstone, both pumiceous and of the white or "ghost," variety, and the presence of the shale-ball irons embedded in the heterogeneous mass of rock detritus to a depth in some cases of upward of 20 feet, can not be satisfactorily accounted for on the blow-out hypothesis. To explain these phenomena, the following is presented:

Hypothetical Considerations and Conclusion.—Let one conceive of a spheroidal mass of meteoric iron, perhaps 500 feet in diameter, falling upon the earth at a speed of 5 miles per second. The superficial rocks are crushed and thrown back upon the plain in an amount more than equal to the bulk of the meteorite. Mr. Tilgh-

[1] For these determinations I am indebted to Mr. L. W. Page, of the Bureau of Roads, Department of Agriculture.

man, an authority on impact of projectiles from heavy ordnance, has estimated that in rocks as brittle as those of this particular vicinity the crater formed would be eight to ten times the diameter of the projectile; that is, with a 500-foot projectile the crater might be 4,000 feet in diameter, which is approximately that of the existing crater. As depths below the surface increased, the upward escape of material around the mass would be impeded, and that directly in its path and, to a less extent, that on either side would become enormously compacted. The heat generated by the sudden downward plunge of the body would produce fusion and probably a partial volatilization, and where sufficient moisture was present, other conditions being favorable, would give rise to the pumiceous structure found in the altered sandstone. But certain after-effects must be taken into consideration. That there was moisture is evident by the existence of the pumice. The effect of the impact would be to convert almost instantly this moisture into steam with an enormous explosive power. As a result, quantities—the amount being dependent upon the amount of water—of débris, including even portions of the meteoric fall itself would be ejected and thrown back above the crater rim and scattered widely over the plain. It would seemingly be safe to assume a temporary pseudovolcanic condition.

To this cause the writer would ascribe the formation of the peculiar moraine-like mounds shown in plate LXVIII, figure 1, and indeed all those heterogeneous deposits, composed of rockflour and fragments of limestone and sandstone (a portion of the latter metamorphosed), in which the shale-ball irons are embedded. It is impossible to account for the position of these last in any other way than to assume that they fell at the same period of time as the material in which they lie embedded. The difference in specific gravity of the various materials is such that it is inconceivable that they should have traveled together for any great distance. Their association may be best explained on the assumption that all were poured out together over the crater rim, perhaps in the condition of mud, during this pseudo-volcanic stage. Only on this ground likewise is it possible to explain the presence in these deposits of masses of the altered sandstone. These, seemingly, must have been formed by heat and pressure well down toward the bottom of the crater, and have been brought back to the surface through explosive action, which took place some little time after the meteor came to rest. What proportion of the irons scattered over the plains are the result of this secondary effect one can only surmise. The fact that there is seemingly no regularity in their distribution—as is almost universally the case in meteoric showers, and, in addition, no gradation in size along the supposed line of flight, nor evidence of atmospheric friction upon their surfaces—favors the idea that *all* were thrown out, and it is not impossible that practically the entire mass not dissipated by volatilization was thus ejected. It should be remarked, in this connection, that a most liberal estimate of the material carried away by collectors or still remaining as shale on the plain would scarcely account for a thousandth part of a mass sufficient to form the crater.

The failure thus far to find a large intact mass within the crater might be further explained on the ground that a considerable portion of it was volatilized by the intense heat generated at the moment of striking the surface, and the comparatively small residual remaining has largely succumbed to oxidation. It must be remembered, however, that the method of borings, whereby the materials are brought to the surface by a stream of water forced downward through the drill-pipe is such as to practically preclude the securing of particles of metallic iron of any but the smallest sizes. Even if permitted by the dimensions of the hole, their high specific gravity would cause them to be left behind, and only the lighter sand grains and more minute particles would be brought to the surface.

The work thus far done does not, therefore, disprove the presence of a large quantity of fragmental iron, although tending to show that no large mass lies there buried. It is possible, too, that the estimated size of the body making the crater is an exaggeration, since if, as seems probable, volatilization of a considerable portion followed immediately upon striking the ground, the outrush of vapor due to the enormous expansion in passing from the solid to the gaseous condition would certainly have served to tear away the rock and increase the diameter to an extent that we have no means of estimating.

Acknowledgments

This investigation detailed above has been rendered possible only through the generous and hearty coöperation of Messrs. Barringer and Tilghman, to whom reference has been made so repeatedly that further allusion seems almost superfluous. To Mr. G. K. Gilbert the writer is also indebted for notes, maps, and other materials collected at the time of his studies. To the U. S. Geological Survey he is indebted for prints from Mr. Gilbert's negatives, for a redrawing of the contour map, and for the photomicrographs reproduced in plate LXX. Mr. Holsinger, manager at the crater, has kindly forwarded material as requested and furnished photographs

and important data, and Mr. Tassin, of the Division of Mineralogy, has allowed the use of his unpublished chemical notes.

The investigations in the field were conducted under the auspices of the Smithsonian Institution. A set of specimens of the meteoric irons, altered sandstones, and associated products has been deposited by Messrs. Barringer and Tilghman in the U. S. National Museum, where it is now on exhibition.

U. S. NATIONAL MUSEUM, *November*, 1907.

EXPLANATION OF PLATES

PLATE LXI

FIG. 1. View of crater rim from the northeast.
2. View of crater rim from the south.

PLATE LXII

FIG. 1. View on outer slope of east rim of crater, looking southward.
2. A limestone boulder on outer slope of east rim of crater. Dimensions, 148 feet in circumference at the ground, 23 feet high on west side, 30 feet high on east side. Approximate weight, 3,000 tons.

PLATE LXIII

FIG. 1. View looking northward along crest of west rim of crater.
2. View looking northward along crest of west rim of crater, showing width of crest.

PLATE LXIV

FIG. 1. View looking across the crater; from low place in northern side of rim.
2. View looking across and into the crater; from the south.

PLATE LXV

FIG. 1. Near view of interior wall of crater, looking northward.
2. View looking across the crater from the north and showing the faulting (directly beneath arrow) in southern rim.

PLATE LXVI

Contour map of crater

PLATE LXVII

FIG. 1. Dry wash on south side of outer rim, showing seven-foot bank of rock-flour.
2. Whale Rock, a limestone boulder on outside of west rim. Dimensions, 88 feet in circumference at the ground and 38 feet in maximum height. Approximate weight, 1,500 tons.
3. Largest boulder on rim of crater, west side.

PLATE LXVIII

FIG. 1. Moraine-like hills on outer slope of northern rim of crater.
2. Near view of interior walls of crater, with talus and alluvial fans from the cliffs.

PLATE LXIX

View in interior of crater showing nearly level floor; looking south.

PLATE LXX

View in interior of crater showing a near view of south wall.

PLATE LXXI

Microstructure of gray sandstone

FIG. 1. The unaltered sandstone.
2. First and partial phase of alteration.
3. Completely metamorphosed sandstone.
4. Quartz glass formed by fusion of sandstone.
5. A highly magnified portion of No. 3, showing curved cleavage lines.

PLATE LXXII

Altered sandstone from shafts inside of crater

FIG. 1. Completely metamorphosed sandstone, with secondary platy structure at right angles to bedding.
2. Fused and slightly pumiceous sandstone, almost wholly glass.
3. Pumiceous sandstone, almost wholly glass.
4. Coarsely pumiceous sandstone, almost wholly glass.

PLATE LXXIII

Typical forms of Canyon Diablo meteoric irons

PLATE LXXIV

Etched section of Canyon Diablo iron

PLATE LXXV

Shale-ball irons from trenches on north rim of crater

FIG. 1. Ball consisting of residual nucleus of metallic iron, with adhering fragments of sandstone and limestone.
2. Shale ball cut in halves and showing metallic nucleus, with its crust of iron shale.

NOTES ON GONIDEA ANGULATA LEA, A FRESH-WATER BIVALVE, WITH DESCRIPTION OF A NEW VARIETY

By WM. H. DALL

Curator, Division of Mollusks, U. S. National Museum

The National Museum contains the original type of Lea, the type of Gould's *A. feminalis,* a cotype of *A. randalli* Trask, and specimens agreeing well with the figure of Sowerby's *A. biangulata,* together with a good series from some twenty different localities, ranging from Spokane, Wash., south to Los Angeles, Cal. These specimens show the species to occur in the watersheds of the Columbia River and its branches, of the Umpqua River, of the Sacramento and San Joaquin rivers, the Santa Clara Valley, and the valley of Los Angeles.

All the named forms are markedly angular; the secondary radial rib present in all of them is especially prominent in the form called *biangulata* by Sowerby.

The valves may be compressed or inflated, the angle may be blunt or carinate, the posterior end, always wider than the anterior, may be very or only moderately wide, dorsally alate or merely angular. The anterior end is short and rounded or, in some specimens, very attenuate and almost pointed.

The periostracum is yellowish brown, darker in the older parts, varying to black; when light it is frequently elegantly rayed with dark green. The hinge teeth are conspicuous in the young, but obsolete in the adult; the surface is more or less concentrically undulate. The nacre is livid bluish white or with a salmon-colored flush in the concavity of the valve, all salmon-colored, or elegant purple partially or throughout. The maximum length was 5¾ inches; a specimen in the collection 4.5 inches in length has a width of 2⅜ inches, but the majority are more slender. The young, 40 mm. long, may have a well-developed lateral carina or be entirely destitute of angulation.

Mr. Harold Hannibal, of Santa Clara County, California, has recently sent to the Museum a fine series of specimens from Guadalupe Creek, between San José and San Francisco Bay, which are remarkable for the almost total absence of lateral angulation, their large size, compressed form, and freedom from erosion. Hardly any trace of the angulation is left, and in this character all agree;

also in having the anterior end but slightly attenuated. An average specimen measures 116 mm. long, 42 mm. wide at the beaks, and 52 mm. wide at the posterior dorsal angle, with a maximum diameter of 28 mm. The corresponding measurements for a specimen of the typical form are: 92.0, 33.0, 45.0, and 30.0 mm.

Lea, in his original description, mentions the radiations, which are still faintly visible on his type, collected nearly three-quarters of a century ago. In the generic diagnosis of *Gonidea* in the Synopsis of the Naiades (Proc. U. S. Nat. Mus., XXII, p. 657) we find the expression "epidermis rayless"—an inadvertence which should be corrected.

In his communication, Mr. Hannibal gives the following interesting data as to the habits of the species in his locality: It is found in "sloping clay banks, between four inches and two feet below the water level. They dig close to the surface a horizontal burrow, perhaps three times their length or less, with a sloping ditch down the slope [of the bank], which they stay in when the water level falls in summer. They are sometimes solitary, but usually there are two or three very large ones and several small ones in the same burrow, where they brace themselves very tightly. A twenty-five-yard-long clay bank will often yield forty or fifty big fellows for dissection work. One exception to this *situs* was found in an artificial pond with brick walls, mud bottom, and inhabited by ducks. Here scattered big fellows might be found all over the bottom, where they had been washed in at the time of high water, and later were unable to get out."

It may be added that Mr. Henry Hemphill found the strongly angulated form of the species imbedded to the level of the angle or carina, in rapid streams, so that material carried along by the current would slip easily over the flattened surface of the end of the valves without disturbing the animal or eroding the shell.

The form discovered by Mr. Hannibal presents such a contrast to the angulate type of the species that in the absence of connecting links it might easily be taken for a new species, and to distinguish it from the typical *angulata* I would propose for it the name of variety *haroldiana*. Types of the variety are No. 110,596, U. S. Nat. Mus.

A NEW SPECIES OF CAVOLINA, WITH NOTES ON OTHER PTEROPODS

By WM. H. DALL

Curator, Division of Mollusks, U. S. National Museum

Having had occasion lately to revise the dry specimens of Thecosomatous Pteropods in the National Museum, in which the collection proved unexpectedly rich, several specimens of a species of *Cavolina* (= *Hyalœa*) were found which could not be assigned to any of the recognized species.

CAVOLINA COUTHOUYI, n. sp.

Shell of moderate size, colorless, transparent, inflated, widest at the posterior transverse line of the lateral sinuses; shell in the median line behind blunt, wide, evenly rounded off, with no median spine, the median portion projecting slightly beyond the straight posterior margin of the lateral angles; ventral plate dome-like, the lateral angles triangular, slightly bent dorsally; the lateral clamps as usual in the genus, the anterior lip narrow, slightly reflected backward over a rather wide, strong constriction; surface ornamented with regular, slightly elevated concentric lines, with wider interspaces, which become less wide toward the front; dorsal plate longer, its anterior margin evenly arched over the ventral lip, very slightly produced, with a shallow median, narrow gutter; sculpture of the back with three subequal, low, radial ribs with shallow, wider interspaces, and fine radial striæ crossed by incremental lines; the median rib arching evenly over to the posterior margin of the dorsal lip. Length, 7; width, 7; maximum dorso-ventral diameter, 4.5 mm.

Fiji Islands, A. Garrett, U. S. Nat. Mus., 110,595; New South Wales, Couthouy, on the Wilkes Exploring Expedition, U. S. Nat. Mus., 18,050.

This species has the posterior end rounded as in *C. longirostris,* but the form of the aperture, the sculpture of the back, and the characters of the lateral angles form a combination unlike any of the described species. All the specimens are very uniform in character.

It may be noted that the name of *australis* (*Clio*) given by D'Orbigny in 1836 and used in the *Challenger* Report was used in 1792 by Bruguière for a species now referred to *Clione.* The later name must therefore he rejected, and for it I would propose the name of *Clio antarctica.*

In examining numerous specimens of *Peracle reticulata* Orbigny and *P. bispinosa* Pelseneer, I find that, as Pelseneer suspected might be the case, the thin layer comprising the reticulation, while not exactly corresponding to the periostracum, is nevertheless dehiscent, and we have several specimens of *bispinosa* which partially retain it. The reticulation is sometimes partly hexagonal and partly quadrangular on the same specimen, and is more or less calcareous. The puckered sutural margination, which was supposed to be characteristic of *P. bispinosa,* often appears only late in life, the spine on the lip only with complete maturity, so that it is probable that *bispinosa* is only a completely developed mature phase of *reticulata.* It is also likely that *Limacina triacantha* Fischer should be referred to the genus *Peracle,* from which the shell seems to differ only by its less elevated spire.

Heterofusus peponum Gould is the fry of a Gastropod, probably a species of *Lampusia.* This determination is made from Gould's type. *Limacina helicina* Phipps, which is admirably figured by Sars (Moll. Reg. Arct. Norveg., pl. 29), is instantly distinguishable from *L. pacifica* Dall by its surface sculpture, which in the former is uniform, close, and regular, while in the latter the axial striæ are sparse, distant, and irregular—in fact, nearly obsolete. *Heterofusus balea* and *retroversus* may also be easily distinguished, as Sars' contrasting figures indicate. *Clione dalli* Krause, from Bering Strait, is certainly an immature animal and probably, as believed by Pelseneer, the young of *Clione limacina* Phipps. *Clione elegantissima* Dall, from the North Pacific, is, however, a much smaller and fully mature animal, with no resemblance in form, color, or details of its external structure to *C. limacina* at any stage of its development. No one familiar with both in the living state could possibly confound the two species; but specimens preserved in spirits are subject to such irregular contraction and modification that any one knowing them only by such distorted material must necessarily be more or less misled as to their natural appearance.

A PRELIMINARY TREATMENT OF THE OPUNTIOIDEAE OF NORTH AMERICA

By N. L. BRITTON and J. N. ROSE

In 1904 the writers began a joint study of the Cactaceae of North America. As early as 1897, however, Dr. Rose had begun to send living specimens to Washington. Through the kindness of Dr. B. T. Galloway, Chief of the Bureau of Plant Industry, and Mr. Frederick V. Coville, Botanist of the U. S. Department of Agriculture, arrangements were made to properly care for this collection. It has grown until it now comprises about 5,000 individual plants, filling the greater part of a greenhouse 25 by 100 feet. Some 500 plants have died and these have been preserved as skeleton specimens in the U. S. National Museum. Dr. Britton, on the other hand, upon the organization of the New York Botanical Garden, began also to make a collection of living Cacti. He has now accumulated a large study series and a most attractive exhibition series. The latter is especially fine on account of the number of large species, not a few of which are new to our American collections. These two collections are very rich in species of Opuntia and allied genera, and it seems desirable to present a preliminary treatment of the group at this time. The species here enumerated are those of which we have actually examined living plants or specimens, or which from our study of descriptions and illustrations there seems every reason to believe should be recognized. Our collections indicate several new species, only a part of which are here described. The type species is *Cactus opuntia* L.

We have accepted, in general, the several series of Opuntia as recognized by the late Professor Schumann, but with considerable modification and with several transpositions of species.

We recognize three genera, belonging to the subfamily Opuntioideae in North America, including Central America and the West Indies. The species of Opuntia and Nopalea are listed below, while those of Pereskiopsis will be found on pages 331-333 of this volume.

LIST OF THE SPECIES OF OPUNTIA

Series CLAVATAE

The series appears to be well characterized by the sheathless spines.

OPUNTIA BRADTIANA (Coult.) K. Brandeg.

Cereus bradtianus COULT. Contr. Nat. Herb. 3: 406. 1896 (April).
Grusonia cereiformis F. REICHB. Monatsschr. Kakteenk. 6: 177. 1896 (August).
Opuntia bradtiana K. BRANDEG. Erythea 5: 121. 1897.
Opuntia cereiformis WEBER in Bois, Dict. Hort. 897. 1898.

Type locality: Plains of Coahuila.
Distribution: Coahuila, Mexico.
Illustration: Schum. Gesamtb. Kakteen *fig. 101.*

OPUNTIA INVICTA Brandeg.

Opuntia invicta BRANDEG. Proc. Cal. Acad. II. 2: 163. 1889.

Type locality: San Juanico, Lower California.
Distribution: Lower California.
Illustration: Cact. Journ. 1: 2.

OPUNTIA PULCHELLA Engelm.

Opuntia pulchella ENGELM. Trans. St. Louis Acad. 2: 201. 1863.

Type locality: Sandy deserts on Walker River, Nevada.
Distribution: Nevada and Arizona.

OPUNTIA BULBISPINA Engelm.

Opuntia bulbispina ENGELM. Proc. Am. Acad. 3: 304. 1856.

Type locality: Saltillo, Mexico.
Distribution: New Mexico to Coahuila.
Illustration: Cact. Mex. Bound. *pl. 73. figs. 5, 6.*

OPUNTIA GRAHAMI Engelm.

Opuntia grahami ENGELM. Proc. Am. Acad. 3: 304. 1856.

Type locality: Sandy bottoms of the Rio Grande near El Paso, Texas.
Distribution: New Mexico and Texas.
Illustration: Cact. Mex. Bound. *pl. 72.*

OPUNTIA EMORYI Engelm.

Opuntia emoryi Engelm. Proc. Am. Acad. **3**: 303. 1856.

Type locality: Arid soil, El Paso, Texas.
Distribution: Western Texas to Arizona and northern Mexico.
Illustrations: Cact. Mex. Bound. *pls. 70, 71;* Cact. Journ. **1**: 154.

OPUNTIA SCHOTTII Engelm.

Opuntia schottii Engelm. Proc. Am. Acad. **3**: 304. 1856.

Type locality: Arid soil near the mouth of the San Pedro and Pecos, western Texas.
Distribution: Southern Texas and northern Mexico.
Illustration: Cact. Mex. Bound. *pl. 73. figs. 1–3.*

OPUNTIA SCHOTTII GREGGII Engelm.

Opuntia schottii greggii Engelm.; Coult. Contr. Nat. Herb. **3**: 444. 1896.

Type locality: San Luis Potosi.
Distribution: Only known from type collection.
Illustration: Cact. Mex. Bound. *pl. 73. fig. 4.*

OPUNTIA CLAVATA Engelm.

Opuntia clavata Engelm. in Wisliz. Mem. North. Mex. 95. 1848.

Type locality: Albuquerque, New Mexico.
Distribution: Nevada and New Mexico.
Illustrations: Pac. R. Rep. **4**: *pl. 22. figs. 1–3; pl. 24. fig. 6;* Cact. Mex. Bound. *pl. 73. figs. 5, 6.*

OPUNTIA PARRYI Engelm.

Opuntia parryi Engelm. Am. Journ. Sci. II. **14**: 339. 1852.

Type locality: Plains of the Mohave River, California.
Distribution: Southern California.
Illustrations: Pac. R. Rep. **4**: *pl. 22. figs. 4–7;* Cact. Journ. **1**: 132.

OPUNTIA KUNZEI Rose, sp. nov.

Stem 10 to 15 cm. high, much branched; joints somewhat clavate, light bluish green, 8 to 10 cm. long, strongly tubercled; spines numerous, the longest 4 cm. long, somewhat reddish when young; leaves linear, acute, 8 to 10 mm. long; flowers deeply set in the apex of the joint-like ovary, fragant, 2.5 cm. long, 4 to 5 cm. broad when fully open; sepals reddish in bud, ovate, acuminate; petals pale yellow; fruit yellowish, 4 to 8 cm. long, oblong to clavate, sometimes proliferous, the areoles large, white, bearing a fringe of white bristles; seeds white, 4 to 5 mm. in diameter, the commissure very indistinct.

Type in U. S. National Herbarium, no. 535,063, collected by Dr. R. E. Kunze in Pima County, Arizona, 1904.

Perhaps nearest *O. grahamii,* but with larger and different joints and different spines.

The species is named for Dr. Kunze, a valued correspondent and an enthusiastic cactus collector. He has furnished the following interesting data regarding this species:

I found this plant about forty miles south of the Ajo copper mines, in the southwestern part of Pima County, Arizona, and only about 25 to 35 miles north of the Mexican boundary. Immense tracts between the smaller arroyos are covered by this species, and for miles my guide led us through stretches of desert in the Gunsight Mining District, a waterless region, little known except to prospectors. On the eastern slope of the Gunsight Mountain range I collected *Cereus thurberi,* which species has its northern limit at the Ajo copper mines, Ajo being 60 miles south of Gila Bend, on the Southern Pacific Railroad. All the plants of *O. kunzei* were covered with the *Coccus cacti* to such an extent that I was obliged to collect a basketful of such or go without any. My former partner, Mr. L. Kunze, had found this Opuntia about the same time, 20 to 25 miles south of Casa Grande, in Pinal County, and all plants he brought in were completely covered with Coccus. I succeeded in cleaning only a few plants for cultivation. Those which I collected I threw into a pit, covered the mass with a peck of fine unslaked lime, and two weeks later removed a dozen live and clean plants. I will send you shortly a young plant of *O. kunzei* with an unopened flower bud. I shall try to preserve one of the flowers for you in formaldehyde solution of 2 per cent strength, as well as the fruit.

I thought the spines resembled *Opuntia grahami,* but find it different in shape of fruit as well as in thickness of its rootstock. I compared it with the cut in Cactaceae of Mexican Boundary Report. I have therefore no plant of *O. grahami.*

Series CYLINDRICAE

Further study is necessary to effect a natural grouping of the species. We include in this group the three series Cristatae, Humiliores, and Deciduae of Professor Schumann, which are clearly not natural ones, the relative size and number of the tubercles proving to be quite unsatisfactory characters.

OPUNTIA TUNICATA (Lehm.) Link & Otto

Cactus tunicatus LEHM. Ind. Sem. Hort. Hamburg 6. 1827.
Opuntia exuviata DC. Mem. Mus. Paris 17: 118. 1828.

Opuntia furiosa WENDL. Cat. Herrenh. 1835.
Opuntia tunicata LINK & OTTO; Pfeiff. Enum. Cact. 170. 1837.
Opuntia hystrix GRISEB. Cat. Pl. Cub. 117. 1866.

Type locality: In Mexico, but at first supposed to have come from Brazil.

Distribution: Northern Mexico, in the States of Coahuila and San Luis Potosi; Cuba, apparently cultivated; Ecuador (see Schumann, Monatsschr. Kakteenk. **8**: 156); Chili (see Söhrens, op. cit. **10**: 6).

OPUNTIA PALLIDA Rose, sp. nov.

Stems 5 cm. in diameter, about one meter high, with widely spreading branches, the whole plant often broader than high; old areoles very spiny, often bearing 20 spines or more, these often 3 to 4 cm. long with white papery sheaths; young areoles bearing few spines; ovary tubercled, the areoles either naked or bearing a few bristly spines; flowers pale rose-colored; petals 15 mm. long.

Type in U. S. National Herbarium, no. 451,783, collected by J. N. Rose and Jos. H. Painter near Tula, Hidalgo, Mexico, July 3, 1905 (no. 8290). Additional specimens were collected by E. W. Nelson at the same station, June, 1896 (no. 3879).

This species grows interspersed with *O. imbricata*, but is much lower in stature and has smaller leaves and lighter-colored flowers. It is much more like *O. tunicata*, but that species has yellow flowers and is always smaller.

Illustration: Contr. Nat. Herb. **10**: *pl. 17. A.*

OPUNTIA IMBRICATA (Haw.) DC.

Cereus imbricatus HAW. Rev. Pl. Succ. 70. 1821.
Opuntia imbricata DC. Prod. **3**: 471. 1828.
Opuntia rosea DC. Mem. Mus. Paris **17**: 118. 1828.
Opuntia decipiens DC. Mem. Mus. Paris **17**: 118. 1828.
Opuntia exuviata DC. Mem. Mus. Paris **17**: 118. 1828, in part.
Opuntia stellata SALM-DYCK, Cact. Hort. Dyck. 50. 1842.
Opuntia cristata SALM-DYCK, Cact. Hort. Dyck. 50. 1842.

Type locality: Unknown; introduced into England by Loddiges in 1820.

Distribution: Central Mexico.

OPUNTIA ARBORESCENS Engelm.

Cactus cylindricus JAMES, Cat. 182. 1825, not Haw.
Cactus bleo TORR. Ann. Lyc. N. Y. **2**: 202. 1828, not H. B. K.
Opuntia arborescens ENGELM. in Wisliz. Mem. North. Mex. 90. 1848.

Type locality: No station given.

Distribution: South Central United States and northern Mexico.

Illustrations: Pac. R. Rep. **4**: *pl. 17. figs. 5, 6; pl. 18. fig. 4; pl. 24. fig. 12;* Cact. Mex. Bound. *pl. 75. figs. 16, 17.*

OPUNTIA THURBERI Engelm.

Opuntia thurberi ENGELM. Proc. Am. Acad. **3**: 308. 1856.

Type locality: Bacuachi, Sonora.
Distribution: Sonora.

OPUNTIA WHIPPLEI Engelm. & Bigel.

Opuntia whipplei ENGELM. & BIGEL. Proc. Am. Acad. **3**: 307. 1856.

Type locality: About Zuni, New Mexico.
Distribution: New Mexico and Arizona.
Illustration: Pac. R. Rep. **4**: *pl. 24. figs. 9, 10.*

OPUNTIA SPINOSIOR (Engelm. & Bigel.) Toumey

Opuntia whipplei spinosior ENGELM. & BIGEL. Proc. Am. Acad. **3**: 307. 1856.
Opuntia spinosior TOUMEY, Bot. Gaz. **25**: 119. 1898.

Type locality: South of the Gila River.
Distribution: Arizona and northern Mexico.
Illustration: Gard. & For. **9**: *fig. 1.*

OPUNTIA SPINOSIOR NEOMEXICANA Toumey

Opuntia spinosior neomexicana TOUMEY, Bot. Gaz. **25**: 119. 1898.

Type locality: None given, but Toumey writes: Tucson plains, between Tucson and the Santa Catalina Mountains [Arizona].
Distribution: Southern Arizona.

OPUNTIA ACANTHOCARPA Engelm. & Bigel.

Opuntia acanthocarpa ENGELM. & BIGEL. Proc. Am. Acad. **3**: 308. 1856.

Type locality: On the mountains of Cactus Pass, about 500 miles west of Santa Fe.
Distribution: Arizona and California; reported also from Utah, Nevada, and Sonora.
Illustrations: Pac. R. Rep. **4**: *pl. 18. figs. 1–3; pl. 24. fig. 11;* N. Am. Fauna **7**: *pls. 7, 8.*

OPUNTIA VERSICOLOR Engelm.

Opuntia versicolor ENGELM.; Coult. Contr. Nat. Herb. **3**: 452. 1896.

Type locality: Tucson, Arizona.
Distribution: Arizona and northern Mexico.
Illustration: Bull. Torr. Club **32**: *pl. 9. figs. 4–8.*

OPUNTIA SERPENTINA Engelm.

Opuntia serpentina ENGELM. Am. Journ. Sci. II. **14**: 338. 1852.
Cereus californicus NUTT.; Torr. & Gr. Fl. N. Am. **1**: 555. 1840, not *Opuntia californica* Engelm.

Type locality: Near the seacoast about San Diego, California.
Distribution: Southern California and Lower California.

OPUNTIA ECHINOCARPA Engelm. & Bigel.

Opuntia echinocarpa ENGELM. & BIGEL. Proc. Am. Acad. **3**: 305. 1856.

Type locality: In the Colorado Valley near the mouth of Bill Williams River.
Distribution: Utah, Arizona, and California.
Illustrations: Pac. R. Rep. **4**: *pl. 18. figs. 5–10; pl. 24. fig. 8.*
Professor Coulter recognized the following subspecies:

OPUNTIA ECHINOCARPA MAJOR Engelm.

Opuntia echinocarpa major ENGELM. Proc. Am. Acad. **3**: 305. 1856.
Opuntia echinocarpa robustior COULT. Contr. Nat. Herb. **3**: 446. 1896.

Type locality: In Sonora.
Distribution: Arizona, California, and northern Sonora.

OPUNTIA ECHINOCARPA PARKERI Coult.

Opuntia echinocarpa parkeri COULT. Contr. Nat. Herb. **3**: 446. 1896.

Type locality: In San Diego County, California.
Distribution: Southern California.

OPUNTIA ECHINOCARPA NUDA Coult.

Opuntia echinocarpa nuda COULT. Contr. Nat. Herb. **3**: 446. 1896.

Type locality: San Gregorio, Lower California.
Distribution: Lower California.

OPUNTIA STAPELIAE DC.

Opuntia stapeliae DC. Mem. Mus. Paris **17**: 117. 1828.

Type locality: In Mexico.
Distribution: Mexico.

OPUNTIA DAVISII Engelm. & Bigel.

Opuntia davisii ENGELM. & BIGEL. Proc. Am. Acad. **3**: 305. 1856.

Type locality: Upper Canadian, about Tucumcari Hills, near the Llano Estacado.
Distribution: Texas.
Illustrations: Pac. R. Rep. **4**: *pl. 16;* Bot. Mag. **108**: *pl. 6652.*

OPUNTIA CIRIBE Engelm.

Opuntia ciribe ENGELM.; Coult. Contr. Nat. Herb. 3: 445. 1896.

Type locality: From Comondu and Loreto northward beyond Rosario.
Distribution: Central Lower California.

OPUNTIA TETRACANTHA Toumey

Opuntia tetracantha TOUMEY, Gard. & For. 9: 432. 1896.

Type locality: Five miles east of Tucson, Arizona.
Distribution: Arizona.
Illustration: Bull. Torr. Club 32: *pl. 9. fig. 2.*

OPUNTIA ALCAHES Weber

Opuntia alcahes WEBER, Bull. Mus. Hist. Nat. Paris 1: 321. 1895.

Type locality: In Lower California.
Distribution: Lower California.

OPUNTIA BERNARDINA Engelm.

Opuntia bernardina ENGELM.; Parish, Bull. Torr. Club 19: 92. 1892.

Type locality: From the Coast Range to the San Bernardino Mountains, California.
Distribution: Southern California.

OPUNTIA TESAJO Engelm.

Opuntia tesajo ENGELM.; Coult. Contr. Nat. Herb. 3: 448. 1896.

Type locality: In Lower California.
Distribution: Lower California.

OPUNTIA PROLIFERA Engelm.

Opuntia prolifera ENGELM. Am. Journ. Sci. II. 14: 338. 1852.

Type locality: Arid hills about San Diego, California.
Distribution: California and Lower California.

OPUNTIA CHOLLA Weber

Opuntia cholla WEBER, Bull. Mus. Hist. Nat. Paris 1: 231. 1895.

Type locality: In Lower California.
Distribution: Lower California.

OPUNTIA FULGIDA Engelm.

Opuntia fulgida ENGELM. Proc. Am. Acad. 3: 306. 1856.

Type locality: Mountains of western Sonora.
Distribution: Nevada to Sonora.
Illustrations: Cact. Mex. Bound. *pl. 75. fig. 18;* Bull. Torr. Club 32: *pl. 9. fig. 1.*

OPUNTIA MAMILLATA Schott

Opuntia mamillata SCHOTT; Engelm. Proc. Am. Acad. 3: 308. 1856.
Opuntia fulgida mamillata COULT. Contr. Nat. Herb. 3: 449. 1896.

Type locality: On the Sierra Babuquibari in Sonora.
Distribution: Arizona and Sonora.

OPUNTIA BIGELOVII Engelm. & Bigel.

Opuntia bigelovii ENGELM. & BIGEL. Proc. Am. Acad. 3: 307. 1856.

Type locality: Bill Williams River, Arizona.
Distribution: Arizona, California, Sonora, and Lower California.
Illustration: Pac. R. Rep. 4: *pl. 19. figs. 1–7.*

OPUNTIA MOLESTA Brandeg.

Opuntia molesta BRANDEG. Proc. Cal. Acad. II. 2: 164. 1890.

Type locality: San Ignacio, Lower California.
Distribution: Lower California.

OPUNTIA CALMALLIANA Coult.

Opuntia calmalliana COULT. Contr. Nat. Herb. 3: 453. 1896.

Type locality: Calmalli, Lower California.
Distribution: Lower California.
Referred by Mrs. Brandegee in Erythea 5: 122, to the preceding species.

OPUNTIA CLAVELLINA Engelm.

Opuntia clavellina ENGELM.; COULT. Contr. Nat. Herb. 3: 444. 1896.

Type locality: Near Mission Purissima, Lower California.
Distribution: Only known from type material.
Likewise referred by Mrs. Brandegee to *O. molesta.*

Series MONACANTHAE

Stems very slender; spines usually solitary.

OPUNTIA KLEINIAE DC.

Opuntia kleiniae DC. Mem. Mus. Paris **17**: 118. 1828.
Opuntia wrightii ENGELM. Proc. Am. Acad. **3**: 308. 1856.

Type locality: Mexico.
Distribution: Texas to Central Mexico.

OPUNTIA LEPTOCAULIS DC.

Opuntia leptocaulis DC. Mem. Mus. Paris **17**: 118. 1828.
Opuntia ramuliflora SALM-DYCK, Hort. Dyck. 360. 1834.
Opuntia vaginata ENGELM. in Wisliz. Mem. North. Mex. 100. 1848, in part.
Opuntia frutescens ENGELM. Bost. Journ. Nat. Hist. **5**: 208. 1845.
Opuntia virgata LINK & OTTO; Pfeiff. Enum. Cact. 173. 1837.
Opuntia gracilis PFEIFF. Enum. Cact. 172. 1837.

Type locality: In Mexico.
Distribution: South Central United States to southern Mexico.
Illustrations: Pac. R. Rep. **4**: *pl. 20. figs. 1–5; pl. 24. figs. 16–19;* Cact. Journ. **1**: 154; Bull. Torr. Club **32**: *pl. 10. fig. 9.*
Two varieties are usually recognized.

OPUNTIA RAMOSISSIMA Engelm.

Opuntia ramosissima ENGELM. Am. Journ. Sci. II. **14**: 339. 1852.
Opuntia tessellata ENGELM. Proc. Am. Acad. **3**: 309. 1856.

Type locality: In California, "near the Colorado."
Distribution: Arizona, California, and Sonora.
Illustrations: Pac. R. Rep. **4**: *pl. 21; pl. 24. fig. 20;* Encycl. Am. Hort. **3**: *fig. 1549;* Cact. Journ. **1**: 2.

OPUNTIA ARBUSCULA Engelm.

Opuntia arbuscula ENGELM. Proc. Am. Acad. **3**: 309. 1856.

Type locality: On the lower Gila near Maricopa village.
Distribution: Arizona and Sonora.
Illustration: Bull. Torr. Club **32**: *pl. 9. fig. 3.*

Series CRUCIFORMES (Subgenus CONSOLEA)

This is a sharply defined and homogeneous group with some claim for consideration as a genus, as proposed by Lemaire.

OPUNTIA SPINOSISSIMA Mill.

Opuntia spinosissima MILL. Gard. Dict. ed. 8. no. 8. 1768.

Type locality: Jamaica.
Distribution: Jamaica.

OPUNTIA CATACANTHA Link & Otto

Opuntia catacantha LINK & OTTO; Pfeiff. Enum. Cact. 166. 1837.

Type locality: St. Thomas.
Distribution: St. Thomas, Culebra, Porto Rico.
Illustration: Journ. N. Y. Bot. Gard. 7: *fig. 6.*

OPUNTIA HAITIENSIS Britton, sp. nov.

? *Cactus ferox* WILLD. Enum. Hort. Berol. Suppl. 35. 1813.
? *Opuntia ferox* HAW. Suppl. Pl. Succ. 82. 1819, not Nutt. 1814.

Trunk somewhat flattened above, 3 to 4 meters high, branching at the top, densely armed with acicular yellowish or gray spines 12 cm. long or less, their bases clothed with yellowish white wool 1 to 2 cm. long; branches obliquely linear-oblong to obovate, 1 to 3 cm. long, 13 cm. wide or less, about 1 cm. thick, obtuse, the areoles somewhat elevated, 1 to 1.5 cm. apart, those of young joints bearing near the edges 3 to 6 acicular spines 1 to 2.5 cm. long, those on the sides of the young joints spineless or with 1 to 3 spines, and with small tufts of grayish wool; older joints bearing at all areoles 5 to 8 gray spines similar to those of the trunk, and brown glochides 6 or 8 mm. long; flowers about 2.5 cm. broad; sepals as broad as long, or broader, apiculate; petals yellow to orange, ovate, apiculate, spreading; stamens much shorter than the petals; ovary cylindric to obovoid-cylindric, terete or nearly so, 4 to 5 cm. long, its distinctly elevated areoles close together, only 5 or 6 mm. apart, bearing brown glochides 2 mm. long, but no spines.

Gonaives, Haiti, 16 meters altitude, George V. Nash and Norman Taylor, no. 1766, August 16, 1905. Description drawn from living plants and formalin and herbarium specimens at the New York Botanical Garden.

Opuntia ferox is said by Pfeiffer to be of South American origin. Willdenow's description calls for long wool at the areoles, which this Haitian plant has on those of the stem.

OPUNTIA MILLSPAUGHII Britton, sp. nov.

Trunk terete, 7 cm. thick at base, 5 cm. thick at top, 60 cm. high or less, branching at the summit, the branches divaricate-ascending, narrowly oblong, much compressed, 40 cm. long or less, 5 to 10 cm. wide, 1 to 1.5 cm. thick, light green; branchlets obliquely lanceolate, obtuse, as wide as the branches, but shorter, 1 cm. thick or less, floriferous at and near the apex; areoles of the older branches pitted, about 1 cm. apart, those of very young shoots slightly elevated, the glochides very short, yellow-brown; spines of the trunk 15 cm. long or less, very numerous and densely clothing the trunk, very slender, gray, mostly strongly reflexed, pungent, those of the branches and branchlets restricted to the areoles on their edges, shorter than those of the trunk, but similar, those of the fruit yellow gray, 2 cm. long or less; flowers cupulate, crimson lake, 1 cm. wide; sepals fleshy, ovate, acute, 4 mm. long and wide; petals erect-ascending, obovate, mucronulate, about 4 mm. wide; stamens half as long as the corolla; style about as long as the corolla; stigma oblong, yellowish crimson; fruit compressed-obovoid, 2 cm. long, 1.5 cm. thick, bearing one or two spines at most of the areoles.

Type in N. Y. Botanical Garden, Britton & Millspaugh, no. 5578.

On nearly flat and smooth limestone rocks, along road across Eleuthera Island, at Rock Sound, Bahamas, Britton & Millspaugh 5578, February 22, 1907; Thatch Cay, Long Island, Bahamas, Britton & Millspaugh 6288.

The species is most nearly related to *Opuntia nashii* Britton, now known to be widely distributed in the Bahamas. It differs from this in its spreading rather than erect or ascending branches, in its very much more abundant and formidable armament, in the shape of the joints, and in the pitted areoles, which are spineless except at and near the edges of the joints. The roots of this plant spread out for a distance of nearly a meter from the base of the trunk on the flat limestone surface. We were fortunate in securing excellent living specimens and in transporting them, nearly unbroken, to the New York Botanical Garden.

OPUNTIA NASHII Britton

Opuntia nashii Britton, Bull. N. Y. Bot. Gard. **3**: 446. 1905.

Type locality: Inagua, Bahamas.
Distribution: Bahama Islands.
Illustration: Journ. N. Y. Bot. Gard. **6**: *fig. 3*.

OPUNTIA RUBESCENS Salm-Dyck

Opuntia rubescens Salm-Dyck; DC. Prod. **3**: 474. 1828.

Type locality: Brazil (?).
Distribution: Island of Culebra; Montserrat; South America (?).

Culebra and Montserrat plants agree nearly with the description of this spineless species, which clearly belongs with the Cruciformes, as pointed out by Berger, rather than with the South American series Inarmatae, where it was placed by Schumann.

O. leucacantha Link & Otto, *O. subferox* Schott, and *O. leucosticta* Wendl. are all cited as Mexican, and are not known to us.

Series PUBESCENTES

Characterized by finely pubescent joints and ovaries; but some glabrous species apparently have to be admitted to it.

OPUNTIA DECUMBENS Salm-Dyck

Opuntia decumbens SALM-DYCK, Hort. Dyck. 361. 1834.
? *Opuntia repens* KARW.; Salm-Dyck. loc. cit.
Opuntia irrorata MART.; Salm-Dyck, Cact. Hort. Dyck. 69. 1850.

Type locality: Mexico.
Distribution: Southern Mexico to Guatemala.
Illustration: Bot. Mag. *pl. 3914.*

OPUNTIA BASILARIS Engelm. & Bigel.

Opuntia basilaris ENGELM. & BIGEL. Proc. Am. Acad. **3**: 298. 1856.

Type locality: From Cactus Pass down the valley of the Bill Williams River.
Distribution: Arizona and Sonora.
Illustrations: Pac. R. Rep. **4**: *pl. 13. figs. 1–5; pl. 23. fig. 14;* W. Watson, Cact. Cult. *fig. 76;* Först. Handb. Cact. ed. 2. *fig. 129;* Cact. Journ. **1**: 132.

OPUNTIA BASILARIS RAMOSA Parish

Opuntia basilaris ramosa PARISH, Bull. Torr. Club **19**: 92. 1892.

Type locality: Dry washes and gravelly benches of the Mohave and Colorado deserts.
Distribution: California and Arizona to Utah.
Illustration: Cact. Journ. **1**: 167, as *O. basilaris.*

OPUNTIA TRELEASEI Coult.

Opuntia treleasei COULT. Contr. Nat. Herb. **3**: 434. 1896.

Type locality: Caliente, in the Tehachapi Mountains, California.
Distribution: California.

OPUNTIA TRELEASEI KERNI Griffiths & Hare

Opuntia treleasei kerni GRIFFITHS & HARE, Bull. N. Mex. Coll. Agr. **60**: 81. 1906.

Type locality: Near Kern, California.
Distribution: Southern California.

OPUNTIA MICRODASYS Lehm.

Opuntia microdasys LEHM. Ind. Sem. Hamburg. 1827.
Opuntia pulvinata DC. Mem. Mus. Paris **17**: 119. 1828.

Type locality: Mexico.
Distribution: Coahuila.

OPUNTIA RUFIDA Engelm.

Opuntia rufida ENGELM. Proc. Am. Acad. **3**: 298. 1856.
Opuntia microdasys rufida SCHUM. Gesamtb. Kakteen 706. 1899.

Type locality: About Presidio del Norte, on the Rio Grande.
Distribution: Texas, Chihuahua.

OPUNTIA MACDOUGALIANA Rose, sp. nov.

Plant about 4 meters high, with a distinct cylindric trunk branching from near the base; joints oblong, 30 cm. long by 8 to 10 cm. broad, softly pubescent; areoles distinct, small; spines generally 4, one much longer (2.5 to 4 cm. long), somewhat flattened, yellowish, becoming whitish in age; glochides short, numerous, yellow; fruit globular to oblong, 5 cm. long, the surface divided into diamond-shaped plates, red, with a broad deep cup at apex, the numerous small rounded areoles filled with clumps of yellow glochides, very rarely with one or two spines.

Type in U. S. National Herbarium, no. 453,485, collected by Rose and Painter near Tehuacan, Mexico, August and September, 1905 (no. 9990).

Named for Dr. D. T. MacDougal, of the Carnegie Institution of Washington, who has photographed many of the cacti of Mexico, including this one, and to whom we are indebted for important coöperation in this investigation.

OPUNTIA NELSONII Rose, sp. nov.

Stems 1 to 4 meters high; joints flattened, oblong to pear-shaped in outline, 15 to 20 cm. long by 10 to 15 cm. broad near the top, pubescent, pale yellowish green in herbarium specimens; areoles 2 to 3 cm. apart; spines 2 to 6, yellow, becoming white in age, very unequal, the longer ones 3 to 4 cm. long; bristles many, yellow, becoming brownish; flowers rather small; petals yellow, 10 to 15 mm. long; ovary pubescent, bearing many yellowish brown bristles; fruit "dark red."

Said to be the common species in the region between Juajuapam, Oaxaca, and Retlatzingo, Puebla, altitude 1,440 to 1,950 meters, where it was collected by E. W. Nelson November 19, 1894 (no.

1981, type); also at mouth of Tomellin Canyon by Rose and Painter, September, 1905 (no. 10,110), and by Rose and Rose, September, 1906 (no. 11,386).

Type in U. S. National Herbarium, no. 569,373.

This species is near *O. puberula,* but with differently shaped joints and different spines.

OPUNTIA DEPRESSA Rose, sp. nov.

Low creeping or spreading plant, sometimes 60 cm. high and forming a patch 3 to 4 meters in diameter; joints of a dark glossy yellowish green color, pubescent; when young, obovate, 20 cm. long, usually with one long, somewhat curved spine at each areole, sometimes with 1 to 3 shorter ones, all yellowish; old joints oblong, 30 cm. long, bearing 4 to 6 spines at the areoles; flowers red; fruit small, globular, with large clusters of brown glochides, when immature with a broad deep umbilicus.

Type in U. S. National Herbarium, no. 453,648, collected by Rose and Painter near Tehuacan, Mexico, 1905 (no. 10,146); also collected by Rose and Rose, 1906 (no. 11,428).

OPUNTIA TOMENTOSA Salm-Dyck

Opuntia tomentosa SALM-DYCK, Obs. Bot. 8. 1822.
Cactus tomentosus LINK, Enum. Hort. Berol. **2**: 24. 1822.
Opuntia oblongata WENDL. Cat. Hort. Herrnh. 1835.

Type locality: Not cited; doubtless Mexico.
Distribution: Mexico.
Illustration: Monatsschr. Kakteenk. **16**: 121.

OPUNTIA PUBERULA Pfeiff.

Opuntia puberula PFEIFF. Enum. Cact. 156. 1837.

Type locality: Mexico.
Distribution: Mexico.

OPUNTIA GOSSELIANA Weber

Opuntia gosseliana WEBER; Schum. Gesamtb. Kakteen Nachtr. 154. 1903.

Type locality: Coast of Sonora on the Gulf of California.
Distribution: Sonora and Lower California.
Illustration: Monatsschr. Kakteenk. **17**: 68.

Placed tentatively in the Pubescentes by Schumann although glabrous. Berger suggests other relationships.[1]

OPUNTIA VELUTINA Weber

Opuntia velutina WEBER, Bull. Mus. Nat. Hist. Paris 10: 389. 1904.

Type locality: In Guerrero.

Distribution: Only known from the type locality. Not seen by us.

OPUNTIA ATROPES Rose, sp. nov.

Plant 1 to 3 meters high, much branched; joints oblong to obovate, 20 to 30 cm. long, deep green, softly pubescent; young joints somewhat glossy; leaves 4 to 5 mm. long, terete in section, acuminate, pubescent, the tips reddish, standing almost at right angles to the joints; areoles circular, filled with short tawny wool; young spines white or yellowish; old spines 3 to 6 cm. long, somewhat angled, standing almost at right angles to the joints, dark yellow or brown at the base, much lighter, often white above; glochides numerous, long, yellow; petals reddish; ovary pubescent, covered with large cushion-like areoles, with few spines or none, truncate at apex.

Type in U. S. National Herbarium, no. 452,103, collected by J. N. Rose and Jos. H. Painter on the lava beds (pedregal) near Yautepec, Morelos, Mexico, July 12, 1905 (no. 8608).

OPUNTIA DURANGENSIS Britton & Rose, sp. nov.

Joints broadly obovate, about 20 cm. long and two-thirds as wide, pale green, glabrous; areoles 1 to 2 cm. apart, elevated, about 5 cm. wide; spines 3 to 5 at each areole, yellow, stiff, pungent, 1.5 cm. long or less, spreading; glochides brown, 2 to 3 mm. long; flowers yellow, about 5 cm. wide; petals obovate, subulate-tipped; ovary 3 to 4 cm. long, finely puberulent, bearing numerous areoles with many glochides and few terete spines; "fruit white or red;" seeds turgid, about 3 mm. wide.

Type in herbarium of N. Y. Botanical Garden, collected in the vicinity of Durango, Mexico, by Dr. E. Palmer, 1896 (no. 212).

OPUNTIA LEUCOTRICHA DC.

Opuntia leucotricha DC. Mem. Mus. Paris 17: 119. 1828.

Type locality: Mexico.

Distribution: Central Mexico.

We place this species in the Pubescentes rather than in the Chaetophorae to which it was referred by Prof. Schumann.

[1] Monatsschr. Kakteenk. 17: 71.

OPUNTIA PYCNANTHA Engelm.

Opuntia pycnantha ENGELM.; Coult. Contr. Nat. Herb. 3:423. 1896.

Type locality: Magdalena Bay, Lower California.
Distribution: Lower California.

OPUNTIA PYCNANTHA MARGARITANA Coult.

Opuntia pycnantha margaritana COULT. Contr. Nat. Herb. 3:424. 1896.

Type locality: Santa Margarita Island, Lower California.
Distribution: Lower California.

An examination of the material in the Brandegee herbarium, both of *pycnantha* and its variety as well as of *O. comonduensis*, showed that they all have pubescent joints and should therefore be transferred to the series Pubescentes.

OPUNTIA COMONDUENSIS (Coult.) Britton & Rose

Opuntia angustata comonduensis COULT. Contr. Nat. Herb. 3:425. 1896.

Type locality: Comondu, Lower California.
Distribution: Southern Lower California.

As pointed out by Mrs. K. Brandegee, this plant has nothing to do with true *O. angustata*, and, as it appears not to have been published as a species heretofore, we now raise Coulter's variety to specific rank. Through the kindness of Mr. Hall and Mr. Brandegee, we have been permitted to examine the type now in the Brandegee herbarium at the University of California. Coulter has labeled two sheets as such, both collected by Mr. Brandegee at Comondu in 1889. One of these has hairy joints and the other is glabrous. The former is selected as the type.

Series CRINIFERAE

Characterized by long wool at the areoles.

OPUNTIA PILIFERA Weber

Opuntia pilifera WEBER in Bois, Dict. Hort. 894. 1898.

Type locality: Mexico.
Distribution: Puebla.

OPUNTIA CRINIFERA Salm-Dyck

Opuntia crinifera SALM-DYCK; Pfeiff. Enum. Cact. 157. 1837.
Opuntia lanigera SALM-DYCK, Cact. Hort. Dyck. 65. 1850.

Type locality: Cited as Brazil, probably erroneously.
Distribution: Mexico.
Illustration: Monatsschr. Kakteenk. **11**: 154.

OPUNTIA SCHEERII Weber

Opuntia scheerii WEBER in Bois, Dict. Hort. 895. 1898.

Type locality: Mexico (?). Unknown to us except by the description.

Series CHAETOPHORAE

Characterized by long weak bristles which are not at all pungent; joints glabrous.

OPUNTIA URSINA Weber

Opuntia ursina WEBER in Bois, Dict. Hort. 896. 1898.

Type locality: Desert of California.
Distribution: Type locality and vicinity.
Illustration: Encycl. Am. Hortic. 3: *fig. 1548.*

Series DIVARICATAE

A group of low, spreading, small-jointed species, the joints falling away readily when shocked.

OPUNTIA CURASSAVICA Mill.

Opuntia curassavica MILL. Gard. Dict. ed. 8. no. 7. 1768.

Type locality: Curacoa.
Distribution: West Indies.
Illustration: Pfeiff. Abbild. Cact. *pl. 6. fig. 2.*

Plants from the island of Culebra, Porto Rico, brought by Drs. Britton and Wheeler to the New York Botanical Garden, almost exactly match Pfeiffer's figure of this species.

OPUNTIA TAYLORI Britton & Rose, sp. nov.

Prostrate, widely branched; joints oblong to narrowly obovate, 12 cm. long or less, turgid, bright green, 3 to 4 cm. wide, 1 to 1.5 cm. thick; areoles 1 to 1.5 cm. apart, not elevated; spines acicular, 3 to 6 at each areole, yellowish brown, becoming white, 4 cm. long or less; glochides yellowish brown, 3 mm. long; flowers yellow, small, the petals about 1 cm. long; ovary pyriform, 1 to 1.5 cm. long, its areoles with few bristles and spineless.

Type in N. Y. Botanical Garden. Collected between Gonaives and La Hotte Rochee, on road to Terre Neuve, Haiti (Nash & Taylor, 1587, August 12, 1905).

Differs from the following species by its turgid joints and more slender spines.

OPUNTIA TRIACANTHA (Willd.) DC.

Cactus triacanthos WILLD. Enum. Suppl. 34. 1813.
Opuntia triacantha DC. Prod. 3: 473. 1828.

Type locality: Not cited; cultivated in the Berlin Garden.

Distribution: Windward Islands, St. Martin to Guadeloupe.

Professor Schumann's description apparently includes two species, one of which belongs here and one in the Albispinosae. Index Kewensis indicates *O. triacantha* as a synonym of *O. curassavica,* which is improbable.

OPUNTIA PES-CORVI Le Conte

Opuntia pes-corvi LE CONTE; Chapm. South. Fl. 145. 1860.

Type locality: Barren sandy places along the coast, Florida and Georgia.

Distribution: Coast of the Southeastern States. Reported from Bermuda, but probably erroneously.

OPUNTIA PUMILA Rose, sp. nov.

Stems low, 30 to 60 cm. high, much branched, the branches readily falling off when touched, velvety pubescent; joints terete in section, or turgid and slightly flattened; areoles small, bearing on old stems several slender spines, the longer ones 3 cm. long; areoles on young joints usually 2, yellowish; ovary pubescent, with few spines or none; petals yellow tinged with red, 15 mm. long; fruit globular, red, 15 mm. long.

Type in U. S. National Herbarium, no. 454,096, collected by J. N. Rose near Oaxaca City, on the road to Mitla, September 5, 1907 (no. 11,306).

For the present we base this species on specimens from a single locality. Our material, however, shows that it, or a group of closely related species, ranges from north Mexico to Guatemala. The specimens examined are all very similar in habit, with narrow, nearly terete branches, but in other respects differ considerably, some being glabrous, while others are velvety-pubescent. We have assigned the species a place in the series Divaricatae, but it seems to resemble some South American species, notably *O. aurantiaca,* more closely than any North American type.

Series MICROCARPAE

According to Schumann, characterized by the small fruit. The two species which he refers here probably do not belong to the same series.

OPUNTIA STRIGIL Engelm.

Opuntia strigil ENGELM. Proc. Am. Acad. 3: 290. 1856.

Type locality: Between the Pecos and El Paso, Texas.
Distribution: Texas.
Illustration: Cact. Mex. Bound. *pl. 67.*

OPUNTIA MICROCARPA Schum.

Opuntia microcarpa SCHUM. Gesamtb. Kakteen 714. 1899.

Type locality: Cul de Sac, Haiti.
Distribution: Known only from the type locality.
Not seen by us. Probably not at all related to *O. strigil.*

This name is a homonym of *O. microcarpa* Engelm.[1] If the species proves to be a good one a new name must be proposed. *Opuntia macracantha* Griseb.[2] from maritime situations in Cuba, was supposed by Professor Schumann to be of this relationship.

Series VULGARES

Prostrate or spreading plants, with few spines at the areoles or unarmed.

OPUNTIA OPUNTIA (L.) Coult.

Cactus opuntia L. Sp. Pl. 468. 1753.
Opuntia vulgaris MILL. Gard. Dict. ed. 8. no. 1. 1768.
Cactus opuntia vulgaris DC. Pl. Succ. Hist. *sub pl. 138.* 1799.
Opuntia italica TENORE, Syll. 241. 1842.
Opuntia intermedia SALM-DYCK, Hort. Dyck. 364. 1850.
Opuntia nana VISIANI, Fl. Dalm. 3: 143. 1852.
Opuntia opuntia COULT. Contr. Nat. Herb. 3: 432. 1896.
Opuntia vulgaris nana SCHUM. Gesamtb. Kakteen 715. 1899.

Type locality: America.
Distribution: Eastern United States.
Illustrations: DC. Pl. Succ. Hist. 2: *pl. 138a;* Bot. Mag. *pl. 2393;* Engelm. & Bigel. Pac. R. Rep. 4: *pl. 10. figs. 1, 2; pl. 23. fig. 13;* Bois, Atl. Pl. Jard. *pl. 124;* Britton & Brown, Ill. Fl. *fig. 2527;* Monatsschr. Kakteenk. 14: 124.

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[1] Engelm. in Emory, Rep. 158. 1848.
[2] Cat. Pl. Cub. 116.

OPUNTIA POLLARDI Britton & Rose, sp. nov.

Apparently prostrate and most nearly related to *Opuntia opuntia;* joints obovate, pale green in dried specimens, about 10 cm. long, 6 cm. wide, and apparently less than 1 cm. thick; areoles 1.5 to 3 cm. apart, bearing numerous brown glochides 2 to 3 mm. long, those toward the top of the joint each with a single stout stiff pungent spine 2.5 to 4 cm. long; fruit short-obovoid, 2.5 cm. long, 1.5 cm. thick, with a few areoles bearing tufts of brownish wool but no spines and but few glochides; seeds 4 to 5 mm. wide, much thicker than those of *O. opuntia.*

Biloxi, Harrison County, Mississippi, August 1, 1896, C. L. Pollard (no. 1138). Type in herbarium of New York Botanical Garden.

OPUNTIA MACRORHIZA Engelm.

Opuntia macrorhiza ENGELM. Bost. Journ. Nat. Hist. **6**: 206. 1850.
Opuntia mesacantha macrorhiza COULT. Contr. Nat. Herb. **3**: 430. 1896.

Type locality: Rocky places on the Upper Guadalupe, Texas.
Distribution: Kansas to Texas.
Illustrations: Pac. R. Rep. **4**: *pl. 12. figs. 7, 8; pl. 23. fig. 6;* W. Watson, Cactus Cult. *figs. 82, 83;* Först. Handb. Cact. ed. 2. *fig. 127.*

OPUNTIA AUSTRINA Small

Opuntia austrina SMALL, Fl. SE. U. S. 816. 1903.

Type locality: Miami, Florida.
Distribution: Florida.

OPUNTIA GREENEI (Coult.) Engelm.

Opuntia mesacantha greenei COULT. Contr. Nat. Herb. **3**: 431. 1896.

Type locality: Golden City, Colorado.
Distribution: Colorado to Arizona.
This species is clearly distinct, but has never been formally given specific rank, although long ago indicated as deserving it by Dr. Engelmann in manuscript.

OPUNTIA STENOCHILA Engelm.

Opuntia stenochila ENGELM. Proc. Am. Acad. **3**: 296. 1856.
Opuntia mesacantha stenochila COULT. Contr. Nat. Herb. **3**: 430. 1896.

Type locality: "Canyon of Zuni," New Mexico.
Distribution: Western New Mexico and Arizona.
Illustrations: Pac. R. Rep. **4**: *pl. 12. figs. 4–6; pl. 23. fig. 9.*

OPUNTIA PLUMBEA Rose, sp. nov.

Plant low, creeping, 10 cm. high, 20 to 30 cm. broad, few-jointed; joints small, nearly orbicular, 3 to 5 cm. in diameter, of a dull lead color, the surface somewhat wrinkled in dead specimens; areoles rather large for the size of the joints; spines pale brownish, slender, usually porrect, often 3 cm. long, mostly 2 in number, rarely as many as 4, sometimes 1 or even wanting; flowers very small, red; ovary naked; fruit 1.5 to 2 cm. long with a few small areoles and these simply woolly; seeds small, rather turgid, smooth, and with a shallow obtuse margin.

Type U. S. National Herbarium, no. 399,804, collected by Mr. F. V. Coville in the San Carlos Indian Reservation, Arizona, altitude 1,500 meters, June, 1904, and for a time growing in Washington.

The fruit and seeds suggest *O. stenochila* Engelm.

OPUNTIA HUMIFUSA Raf.

Cactus humifusus RAF. Ann. Nat. 15. 1820.
Opuntia humifusa RAF. Med. Bot. **2**: 247. 1830.
Opuntia mesacantha RAF.; Ser. Bull. Bot. Geneva 216. 1830.
Opuntia rafinesquii ENGELM. Proc. Am. Acad. **3**: 295. 1856.

Type locality: United States.

Distribution: Central United States.

Illustrations: Pac. R. Rep. **4**: *pl. 10. figs. 3–5; pl. 11;* Fl. des Serres *pl. 2328;* Bot. Mag. *pl. 7041;* Ill. Fl. *2528;* W. Watson, Cactus Cult. *fig. 84;* Am. Entom. & Bot. **2**: *fig. 160;* Först. Handb. Cact. ed. 2. *fig. 126,* as *O. rafinesquii arkansana.*

The following forms, referred to *O. mesacantha* by Dr. Coulter, we have not studied sufficiently to enable us to form opinions as to their relationships:

OPUNTIA MESACANTHA PARVA Coult.

Opuntia mesacantha parva COULT. Contr. Nat. Herb. **3**: 429. 1896.

OPUNTIA MESACANTHA MICROSPERMA (Engelm.) Coult.

Opuntia rafinesquii microsperma ENGELM. Proc. Am. Acad. **3**: 295. 1856.
Opuntia mesacantha microsperma COULT. Contr. Nat. Herb. **3**: 429. 1896.

OPUNTIA MESACANTHA OPLOCARPA Coult.

Opuntia mesacantha oplocarpa COULT. Contr. Nat. Herb. **3**: 431. 1896.

OPUNTIA GRANDIFLORA Engelm.

Opuntia grandiflora ENGELM. Proc. Am. Acad. **3**: 295. 1856.
Opuntia rafinesquii grandiflora ENGELM. Pac. R. Rep. **4**: 55. 1856.

Type locality: On the Brazos River, Texas.
Distribution: Texas.
Illustration: Pac. R. Rep. **4**: *pl. 11. figs. 2, 3.*

Series SUBINERMES

Upright or bushy plants with few spines or none.

OPUNTIA LANCEOLATA Haw.

Opuntia lanceolata HAW. Syn. Pl. Succ. 192. 1812.
Cactus lanceolatus HAW. Misc. Nat. 188. 1803.

Type locality: South America (?).
Distribution: West Indies.

Plants tentatively referred to this species were collected by Drs. Britton and Millspaugh on Cat Island, Bahamas, but the young joints are quite spiny with yellowish spines about 1 cm. long; the old joints become spineless.

OPUNTIA INERMIS DC.

Cactus opuntia inermis DC. Pl. Succ. Hist. **2**: *sub pl. 138.* 1799.
Opuntia inermis DC. Prod. **3**: 473. 1828.
Opuntia vulgaris balearica WEBER in Bois, Dict. Hort. 894. 1897, as synonym.

Type locality: Tropical America.
Distribution: Florida and West Indies.
Illustrations: DC. Pl. Succ. Hist. *pl. 138;* Tussac, Fl. Ant. **2**: *pl. 34.*

We place this species and the preceding one in series Subinermes rather than Vulgares.

OPUNTIA CRASSA Haw.

Opuntia crassa HAW. Suppl. Pl. Succ. 81. 1819.
Opuntia parvula SALM-DYCK, Hort. Dyck. 364. 1834.
Opuntia glaberrima LINK & OTTO; Pfeiff. Enum. Cact. 153. 1837.

Type locality: Mexico (?).
Distribution: Mexico.

OPUNTIA FICUS-INDICA (L.) Mill.

Cactus ficus-indica L. Sp. Pl. 468. 1753.
Opuntia ficus-indica MILL. Gard. Dict. ed. 8. no. 2. 1768.
Opuntia vulgaris TENORE, Syll. Fl. Neap. 239. 1831, not Mill.
Cactus opuntia GUSS. Fl. Sic. Prod. 559. 1827–28, not L.

Type locality: Tropical America.

Distribution: West Indies and tropical America. Naturalized in the Mediterranean region.

Illustrations: Mem. Acad. Neap. 6: *pl. 1, 2;* W. Watson, Cactus Cult. *fig. 80;* Monatsschr. Kakteenk. 15: 151.

OPUNTIA LAEVIS Coult.

Opuntia laevis COULT. Contr. Nat. Herb. 3: 419. 1896.

Type locality: Arizona.

Distribution: Arizona.

Referred by Professor Schumann to *O. inermis,* but not at all like that species.

OPUNTIA LARREYI Weber

Opuntia larreyi WEBER; Coult. Contr. Nat. Herb. 3: 423. 1896.

Type locality: Queretaro, Mexico.

Distribution: Mexico.

Illustration: Bull. N. Mex. Coll. Agr. 64: *pl. 1.*

Series SETISPINAE

Characterized by the low habit, slender, delicate spines, and small joints.

OPUNTIA FILIPENDULA Engelm.

Opuntia filipendula ENGELM. Proc. Am. Acad. 3: 294. 1856.

Type locality: Alluvial bottoms of the Rio Grande near El Paso.

Distribution: Texas, New Mexico, Chihuahua.

Illustrations: Cact. Mex. Bound. *pl. 68;* W. Watson, Cactus Cult. *fig. 81;* Först. Handb. Cact. ed. 2. *fig. 131.*

OPUNTIA SETISPINA Engelm.

Opuntia setispina ENGELM.; Salm-Dyck, Cact. Hort. Dyck. 239. 1850.

Type locality: Pine woods in the mountains west of Chihuahua (fide Engelm. Proc. Am. Acad. 3: 294).

Distribution: Known only from the type locality.

OPUNTIA TENUISPINA Engelm.

Opuntia tenuispina ENGELM. Proc. Am. Acad. 3: 294. 1856.

Type locality: Sand Hills near El Paso, Texas.

Distribution: Type locality and vicinity.

Illustration: Cact. Mex. Bound. *pl. 75. fig. 14.*

Series TUNAE

Bushy plants with abundant yellow spines. The color of the spines is not a wholly satisfactory character.

OPUNTIA CHLOROTICA Engelm. & Bigel.

Opuntia chlorotica ENGELM. & BIGEL. Proc. Am. Acad. 3: 291. 1856.

Type locality: On both sides of the Colorado from San Francisco Mountains to headwaters of Bill Williams River.

Distribution: Arizona, Sonora, New Mexico, Nevada, and California.

Illustration: Pac. R. Rep. 4: *pl. 6, figs. 1–3.*

OPUNTIA CHLOROTICA SANTA-RITA Griffiths & Hare

Opuntia chlorotica santa-rita GRIFFITHS & HARE, Bull. N. Mex. Coll. Agr. 60: 64. 1906.

Type locality: Celero Mountains, Arizona.

Distribution: Arizona.

OPUNTIA TAPONA Engelm.

Opuntia tapona ENGELM.; Coult. Contr. Nat. Herb. 3: 423. 1896.

Type locality: Near Loreto, Lower California.

Distribution: Known only from the type locality.

Doubtfully included in series Tunae.

OPUNTIA PALMERI Engelm.

Opuntia palmeri ENGELM.; COULT. Contr. Nat. Herb. 3: 423. 1896.

Type locality: Near St. George, Utah.

Distribution: Utah.

OPUNTIA BECKERIANA Schum.

Opuntia beckeriana SCHUM. Gesamtb. Kakteen 722. 1899.

Type locality: Probably Mexico.

Distribution: Mexico.

Known to us only from the description.

OPUNTIA LUCAYANA Britton

Opuntia lucayana BRITTON, Bull. N. Y. Bot. Gard. 4: 141. 1906.

Type locality: Grand Turk Island, Bahamas.

Distribution: Grand Turk.

OPUNTIA DILLENII (Ker-Gawl.) Haw.

Cactus dillenii KER-GAWL. Bot. Reg. 3: *pl. 255.* 1818.
Opuntia dillenii HAW. Suppl. Pl. Succ. 79. 1819.

Type locality: Not cited.

Distribution: Coasts of Florida, Bermuda, West Indies, and Vera Cruz.

Illustrations: Dill. Hort. Elth. *pl. 396. fig. 382;* Bot. Reg. loc. cit.; DC. Pl. Succ. Hist. 2: *pl. 137,* as *Cactus cochenillifer.*

OPUNTIA TUNA (L.) Mill.

Cactus tuna L. Sp. Pl. 468. 1753.
Opuntia tuna MILL. Gard. Dict. ed. 8. no. 3. 1768.
Cactus humilis HAW. Misc. Nat. 187. 1803.
Opuntia humilis HAW. Syn. Pl. Succ. 189. 1812.
Opuntia polyantha HAW. Syn. Pl. Succ. 190. 1812.
Cactus polyanthus SIMS, Bot. Mag. 53: *pl. 2691.* 1826.
Opuntia horrida SALM-DYCK; DC. Prod. 3: 472. 1828.

Type locality: Jamaica and tropical America.

Distribution: West Indies.

Illustrations: Dill. Hort. Elth. *pl. 295. fig. 380;* Bot. Mag. loc. cit; Descourt. Fl. Pict. Antilles *pl. 513,* as *Cactus opuntia;* Först. Handb. Cact. ed 2. *fig. 130,* as *O. polyantha.*

Our studies indicate that the common plant of the Jamaica lowlands is to be taken as the type of *Cactus tuna* L.

OPUNTIA CACAPANA Griffiths & Hare

Opuntia cacapana GRIFFITHS & HARE, Bull. N. Mex. Coll. Agr. 60: 47. 1906.

Type locality: Encinal, Texas.

Distribution: Southern Texas.

OPUNTIA LINDHEIMERI Engelm.

Opuntia lindheimeri ENGELM. Journ. Bost. Soc. Nat. Hist. 6: 207. 1850.

Type locality: About New Braunfels, Texas.

Distribution: Texas and Tamaulipas.

Clearly distinct from *O. engelmanni.*

OPUNTIA LINDHEIMERI DULCIS (Engelm.) Coult.

Opuntia dulcis ENGELM. Proc. Am. Acad. 3: 291. 1856.
Opuntia lindheimeri dulcis COULT. Contr. Nat. 3: 421. 1896.

Type locality: Near Presidio del Norte, Texas.

Distribution: Southern Texas.

Illustration: Cact. Mex. Bound. *pl. 75. figs. 5–7.*

OPUNTIA LITTORALIS (Engelm.) Britton & Rose

Opuntia engelmanni littoralis ENGELM. in Brewer & Wats. Bot. Cal. **1**: 248. 1876.
Opuntia lindheimeri littoralis COULT. Contr. Nat. Herb. **3**: 422. 1896.

Type locality: Coast of California, Santa Barbara to San Diego.
Distribution: Coast of southern California.

OPUNTIA CUIJA (Griffiths & Hare) Rose

Opuntia engelmannii cuija GRIFFITHS & HARE, Bull. N. Mex. Coll. Agr. **60**: 44. 1907.

Type locality: San Luis Potosi, Mexico.
Distribution: San Luis Potosi to Queretaro and Hidalgo.
Illustrations: Bull. N. Mex. Coll. Agr. **60**: *pl. 2. figs. 1, 2.*

OPUNTIA OCCIDENTALIS Engelm. & Bigel.

Opuntia occidentalis ENGELM. & BIGEL. Proc. Am. Acad. **3**: 291. 1856.
Opuntia lindheimeri occidentalis COULT. Contr. Nat. Herb. **3**: 421. 1896.

Type locality: Western slopes of the Californian Mountains, between San Diego and Los Angeles.

Distribution: Southwestern California.

Illustrations: Pac. R. Rep. **4**: *pl. 7. figs. 1, 2;* Bull. N. Mex. Coll. Agr. **60**: *pl. 3. fig. 2.*

OPUNTIA MEGALARTHRA Rose, sp. nov.

Plants 1 to 4 meters high, often much branched and the arms widely spreading; joints generally orbicular, very large, often 30 cm. or rarely 50 cm. in diameter, glaucous, bluish green, very thick and turgid; areoles distant, 4 to 6 cm. apart, brownish when young, black in age; spines yellow, 2 to 6 at each areole on young joints, on old joints as many as 8, very stout, 4 cm. long or more, more or less flattened or angled; glochides yellow, numerous; flowers lemon-yellow, 7 to 8 cm. broad; fruit globular, oblong, sometimes 7 cm. long, purplish.

Type in U. S. National Herbarium, no. 453,757, collected at Hacienda Palmar, near Pachuca, Hidalgo, Mexico, by Rose & Painter, July 21, 1905 (no. 10,255).

Distribution: A common and widely distributed species in the States of Hidalgo, Queretaro, Zacatecas, and San Luis Potosi.

Series PROCUMBENTES

Depressed or prostrate plants with yellow spines.

OPUNTIA RUBRIFOLIA Engelm.

Opuntia rubrifolia ENGELM.; Coult. Contr. Nat. Herb. **3**: 424. 1896.

Type locality: St. George, Utah.
Distribution: Only known from the type locality.

OPUNTIA PROCUMBENS Engelm.

Opuntia procumbens ENGELM. Proc. Am. Acad. **3**: 292. 1856.

Type locality: San Francisco Mountains to Cactus Pass, Arizona.
Distribution: Texas to Arizona.
Illustration: Pac. R. Rep. **4**: *pl. 6. figs. 4, 5.*

Series FULVISPINOSAE

Bushy or spreading brown-spined plants, the spines sometimes brown only toward the base; fruits fleshy.

OPUNTIA MEGARRHIZA Rose

Opuntia megarrhiza ROSE, Contr. Nat. Herb. **10**: 126. 1906.

Type locality: Alvarez, Mexico.
Distribution: San Luis Potosi, Mexico.

OPUNTIA NIGRICANS Haw.

Cactus nigricans HAW. Misc. Nat. 187. 1803.
Opuntia nigricans HAW. Syn. Pl. Succ. 189. 1812.
Cactus tuna nigricans SIMS, Bot. Mag. **38**: *pl. 1557.* 1813.

Type locality: Unknown.
Distribution: Mexico.
Illustration: Bot. Mag. loc. cit.

OPUNTIA MACROCENTRA Engelm.

Opuntia macrocentra ENGELM. Proc. Am. Acad. **3**: 292. 1856.

Type locality: Sand hills on the Rio Grande near El Paso.
Distribution: Texas to Arizona and Chihuahua.
Illustration: Cact. Mex. Bound. *pl. 75. fig. 8.*

OPUNTIA PHAEACANTHA Engelm.

Opuntia phaeacantha ENGELM. in Gray, Pl. Fend. **2**: 352. 1849.
Opuntia phaeacantha nigricans ENGELM. Proc. Am. Acad. **3**: 293. 1856.
Opuntia phaeacantha brunnea ENGELM. loc. cit. 1856.

Type locality: About Santa Fe and on the Rio Grande.
Distribution: Texas to Arizona and Chihuahua.
Illustration: Cact. Mex. Bound. *pl. 75. figs. 9–15.*

OPUNTIA PHAEACANTHA MAJOR Engelm.

Opuntia phaeacantha major ENGELM. Proc. Am. Acad. **3**: 293. 1856.

Type locality: Mountainous regions near Santa Fe.

OPUNTIA MOHAVENSIS Engelm.

Opuntia mohavensis ENGELM. Proc. Am. Acad. **3**: 293. 1856.

Type locality: On the Mohave, west of the Colorado, California.
Distribution: Known only from the type locality.
Illustration: Pac. R. Rep. **4**: *pl. 9. figs. 6–8.*

OPUNTIA FUSCOATRA Engelm.

Opuntia fuscoatra ENGELM. Proc. Am. Acad. **3**: 297. 1856.

Type locality: Sterile places of prairies west of Houston, Texas.
Distribution: Known only from the type locality.
Illustration: Pac. R. Rep. **4**: *pl. 11. fig. 4.*

OPUNTIA CAMANCHICA Engelm. & Bigel.

Opuntia camanchica ENGELM. & BIGEL. Proc. Am. Acad. **3**: 293. 1856.

Type locality: Llano Estacado, on the Upper Canadian River.
Distribution: Texas to Colorado and Arizona. Reported from Western Kansas.
Illustrations: Pac. R. Rep. **4**: *pl. 8. figs. 1–5; pl. 22. figs. 12–15;* Ill. Fl. *fig. 2530.*

OPUNTIA TORTISPINA Engelm.

Opuntia tortispina ENGELM. Proc. Am. Acad. **3**: 293. 1856.

Type locality: On the Comanche Plains, near the Canadian River.
Distribution: Nebraska to Texas.
Illustrations: Pac. R. Rep. **4**: *pl. 8. figs. 2, 3; pl. 23. figs. 1–5;* Ill. Fl. *fig. 2529.*

OPUNTIA ENGELMANNI Salm-Dyck

Opuntia engelmanni SALM-DYCK; Engelm. Bost. Journ. Nat. Hist. **6**: 207. 1850.

Type locality: From El Paso to Chihuahua.
Distribution: Chihuahua, New Mexico, Texas.
Illustrations: Cact. Mex. Bound. *pl. 75. figs. 1–4;* Bull. Torr. Club **32**: *pl. 10. figs. 10–13.*

An examination of the plant collected by Wislizenus north of

Chihuahua (no. 223), in the herbarium of the Missouri Botanical Garden, and labeled by Dr. Engelmann as *O. engelmanni* Salm-Dyck, shows that this species is of the series Fulvispinosae, rather than the series Tunae.

OPUNTIA ENGELMANNII CYCLODES Engelm.

Opuntia engelmannii cyclodes ENGELM. Proc. Am. Acad. **3**: 291. 1856.
Opuntia lindheimeri cyclodes COULT. Contr. Nat. Herb. **3**: 422. 1896.

Type locality: "On the Upper Pecos, in New Mexico.

Distribution: Western Texas and New Mexico.

Illustrations: Pac. R. Rep. **4**: *pl. 8. fig. 1; pl. 22. figs. 8, 9.*

OPUNTIA VASEYI (Coult.) Britton & Rose

Opuntia mesacantha vaseyi COULT. Contr. Nat. Herb. **3**: 431. 1896.

Type locality: "Yuma."

Distribution: Southwestern Arizona.

In our opinion clearly of this series rather than Vulgares.

OPUNTIA CYMOCHILA Engelm.

Opuntia cymochila ENGELM. Proc. Am. Acad. **3**: 295. 1856.
Opuntia mesacantha cymochila COULT. Contr. Nat. Herb. **3**: 430. 1896.

Type locality: Along the Canadian River east of Llano Estacado, New Mexico.

Distribution: New Mexico and Arizona.

Illustrations: Pac. R. Rep. **4**: *pl. 12. figs. 1–3; pl. 23. figs. 10–12.*

Likewise to be included in Fulvispinosae rather than Vulgares.

OPUNTIA ANGUSTATA Engelm.

Opuntia angustata ENGELM. Proc. Am. Acad. **3**: 292. 1856.

Type locality: Zuni, New Mexico.

Distribution: Supposed to extend from New Mexico to California, but doubtless not found in California.

Illustration: Pac. R. Rep. **4**: *pl. 7. fig. 3.*

Engelmann's descriptions and illustrations of this species include two, if not three, distinct ones belonging to Fulvispinosae rather than Procumbentes.

OPUNTIA COVILLEI Britton & Rose, sp. nov.

Joints obovate, 10 to 20 cm. long or more; areoles 2 to 4 cm. apart, pale green, sometimes purplish, slightly glaucous; spines slender, somewhat angled, 2 to several from each areole, very unequal, the longer ones 6 cm. long, brownish or yellowish brown throughout; glochides numerous, brown; flowers large, yellow; ovary 4 to 5 cm. long, with few areoles and nearly or quite spineless; fruit more or less tuberculate, red; umbilicus broad and somewhat depressed; seeds 5 mm. broad.

Type in U. S. National Herbarium, no. 40,809, collected at San Bernardino, California, by G. R. Vasey in 1891; also collected by Parish and by Coville in the same region. We are not certain whether all the so-called *O. lindheimeri* from southeastern California belongs here or not, but if so, then here should be referred Engelmann's Californian material referred to *O. angustata.*

Series XEROCARPEAE

Spreading flat-jointed plants with dry or nearly dry fruits.

OPUNTIA SPHAEROCARPA Engelm. & Bigel.

Opuntia sphaerocarpa ENGELM. & BIGEL. Proc. Am. Acad. **3**: 300. 1856.

Type locality: Mountains near Albuquerque, New Mexico.
Distribution: Known only from type locality.
Illustrations: Pac. R. Rep. **4**: *pl. 13, figs. 6, 7; pl. 24, fig. 3.*

OPUNTIA SPHAEROCARPA UTAHENSIS Engelm.

Opuntia sphaerocarpa utahensis ENGELM. Trans. St. Louis Acad. **2**: 199. 1863.

Type locality: Utah Basin.
Distribution: Known only from type locality.

OPUNTIA POLYACANTHA Haw.

Cactus ferox NUTT. Gen. **1**: 296. 1818, not Willd. 1813.
Opuntia polyacantha HAW. Syn. Pl. Succ. Suppl. 82. 1819.
Opuntia media HAW. loc. cit. 1819.
Opuntia missouriensis DC. Prod. **3**: 472. 1828.
Opuntia splendens PFEIFF. Enum. Cact. 159. 1837.

Type locality: Arid situations on the plains of the Missouri.
Distribution: Athabasca to Washington, Nebraska, and New Mexico.
Illustrations: Pac. R. Rep. **4**: *pl. 14. figs. 1–3;* Bot. Mag. *pl. 7046;* Ill. Fl. *fig. 2531.*

The following subspecies recognized by Dr. Coulter have not been sufficiently studied by us to enable us to express opinions concerning their relationships.

OPUNTIA POLYACANTHA PLATYCARPA (Engelm.) Coult.

Opuntia missouriensis platycarpa ENGELM. Proc. Am. Acad. 3: 300. 1856.
Opuntia polyacantha platycarpa COULT. Contr. Nat. Herb. 3: 436. 1896.

Type locality: On the Yellowstone, Montana.

Distribution: Idaho and Montana to Utah, Colorado, and Nebraska.

Illustration: Pac. R. Rep. 4: *pl. 14. fig. 4.*

OPUNTIA POLYACANTHA BOREALIS Coult.

Opuntia missouriensis microsperma ENGELM. & BIGEL. Proc. Am. Acad. 3: 300. 1856. Not *O. rafinesquii microsperma* Engelm. loc. cit. 295.
Opuntia polyacantha borealis COULT. Contr. Nat. Herb. 3: 436. 1896.

Type locality: On the Missouri above Fort Pierre, S. D.

Distribution: "From British Columbia to Oregon and South Dakota."—Coulter.

Illustrations: Pac. R. Rep. 4: *pl. 14. figs. 5–7; pl. 24. figs. 1, 2.*

OPUNTIA POLYACANTHA ALBISPINA (Engelm. & Bigel.) Coult.

Opuntia missouriensis albispina ENGELM. & BIGEL. Proc. Am. Acad. 3: 300. 1856.
Opuntia polyacantha albispina COULT. Contr. Nat. Herb. 3: 437. 1896.

Type locality: Sandy Mountains near Albuquerque, New Mexico.

Distribution: New Mexico and Oklahoma.

Illustrations: Pac. R. Rep. 4: *pl. 14. figs. 8–10; pl. 23. fig. 18.*

OPUNTIA POLYACANTHA WATSONI Coult.

Opuntia polyacantha watsoni COULT. Contr. Nat. Herb. 3: 437. 1896.

Type locality: Wahsatch Mountains, Utah.

Distribution; Nebraska and Wyoming to Colorado, Utah, and New Mexico.

OPUNTIA SCHWERINIANA Schum.

Opuntia schweriniana SCHUM. Monatsschr. Kakteenk. 9: 148. 1899.

Type locality: Near Sapinero, Colorado.

Distribution: Known only from the type locality.

Illustration: Monatsschr. Kakteenk. 9: 148.

This was indicated by Schumann[1] as belonging to the Fulvispinosae, but in his "Keys" to Cactaceae, page 65, is properly placed in the Xerocarpeae, related to *O. polyacantha* (*O. missouriensis*).

[1] Gesamtb. Kakteen. Nachtr. 158.

OPUNTIA TRICOPHORA (Engelm.) Britton & Rose

Opuntia missouriensis tricophora ENGELM. Proc. Am. Acad. 3: 300. 1856.
Opuntia polyacantha tricophora COULT. Contr. Nat. Herb. 3: 437. 1896.

Type locality: Mountains near Albuquerque, New Mexico.
Distribution: New Mexico and Texas.
Illustrations: Pac. R. Rep. 4: *pl. 15, figs. 1–4; pl. 23, fig. 19.*

This species is certainly distinct from *O. polyacantha.* It probably does not belong to this series.

OPUNTIA RHODANTHA Schum.

Opuntia rhodantha SCHUM. Gesamtb. Kakteen 735. 1899.

Type locality: Colorado, at 2,000 to 2,300 meters.
Distribution: Colorado.

OPUNTIA XANTHOSTEMMA Schum.

Opuntia xanthostemma SCHUM. Gesamtb. Kakteen 735. 1899.

Type locality: Mesa Grande, Colorado, 2,000 meters.
Distribution: Colorado.

OPUNTIA HYSTRICINA Engelm. & Bigel.

Opuntia hystricina ENGELM. & BIGEL. Proc. Am. Acad. 3: 299. 1856.

Type locality: Colorado Chiquito and on San Francisco Mountains.
Distribution: New Mexico, Arizona, Nevada, and California.
Illustration: Pac. R. Rep. 4: *pl. 15, figs. 5–7; pl. 23. fig. 15.*

Series TUMIDAE

Low turgid-jointed plants with dry or nearly dry fruits.

OPUNTIA RUTILA Nutt.

Opuntia rutila NUTT.; Torr. & Gr. Fl. N. Am. 1: 555. 1840.
Opuntia erinacea ENGELM. Proc. Am. Acad. 3: 301. 1856.

Type locality: Arid clay hills in the Rocky Mountain range, near the Colorado of the West, about latitude 42°.

Distribution: Wyoming to Arizona and California.

Illustrations: Pac. R. Rep. 4: *pl. 13. figs. 8–11; pl. 24. fig. 4;* Monatsschr. Kakteenk. 14: 105.

The identity of *O. rutila* Nutt. with *O. erinacea* Engelm. was indicated by Dr. Engelmann in the Report of Simpson's Expedition, page 442; Nuttall's type came from southwestern Wyoming and

Engelmann's from the Mohave River. We think it possible that Dr. Engelmann erred in this identification and that *O. rutila* really belongs among the Xerocarpeae.

OPUNTIA ARENARIA Engelm.

Opuntia arenaria ENGELM. Proc. Am. Acad. 3: 301. 1856.

Type locality: Sandy bottoms of the Rio Grande near El Paso.
Distribution: Texas and New Mexico.
Illustration: Cact. Mex. Bound. *pl. 75. fig. 15.*

OPUNTIA FRAGILIS (Nutt.) Haw.

Cactus fragilis NUTT. Gen. 1: 296. 1818.
Opuntia fragilis HAW. Syn. Pl. Succ. Suppl. 82. 1819.

Type locality: "From the Mandans to the mountains, in sterile but moist situations."
Distribution: Wisconsin to Kansas and British Columbia.
Illustrations: Pac. R. Rep. 4: *pl. 24. fig. 5;* Ill. Fl. *fig. 2532;* W. Watson, Cact. Cult. *fig. 78.*

OPUNTIA BRACHYARTHRA Engelm.

Opuntia brachyarthra ENGELM. Proc. Am. Acad. 3: 302. 1856.
Opuntia fragilis brachyarthra COULT. Contr. Nat. Herb. 3: 440. 1896.

Type locality: Inscription Rock, near Zuni, New Mexico.
Distribution: Colorado and New Mexico.
Illustrations: Först. Handb. Cact. ed. 2. *fig. 132;* Cact. Journ. 1: 100.

Series ALBISPINOSAE

Tall or large plants with white spines and broad petals.

OPUNTIA OLIGACANTHA Salm-Dyck

Opuntia oligacantha SALM-DYCK, Cact. Hort. Dyck. 241. 1850.

Type locality: Not cited; cultivated in the Vienna garden.
Distribution: Mexico.

OPUNTIA HYPTIACANTHA Weber

Opuntia hyptiacantha WEBER in Bois, Dict. Hort. 894. 1897.

Type locality: Mexico.
Distribution: Mexico.

OPUNTIA STREPTACANTHA Lemaire

Opuntia streptacantha LEMAIRE, Nov. Gen. & Sp. 62. 1839.
Opuntia pseudo-tuna SCHUM. in Engl. & Prantl. Nat. Pflanzenf. 3[6a]: 201. 1893, not Salm-Dyck.

Type locality: San Luis Potosi.
Distribution: Mexico.
Illustrations: Engl. & Prantl., loc. cit.; U. S. Dept. Agr. Bur. Pl. Ind. Bull. 116: *pl. 1.*

OPUNTIA CANDELABRIFORMIS Mart.

Opuntia candelabriformis MART.; Pfeiff. Enum. Cact. 159. 1837.

Type locality: Mexico.
Distribution: Mexico.

OPUNTIA SPINULIFERA Salm-Dyck

Opuntia spinulifera SALM-DYCK, Hort. Dyck. 364. 1834.

Type locality: Mexico.
Distribution: Mexico.

OPUNTIA ROBUSTA Wendl.

Opuntia robusta WENDL. Cact. Hort. Herrnh. 1835.
Opuntia flavicans LEMAIRE, Nov. Gen. & Sp. 61. 1839.

Type locality: Mexico.
Distribution: Mexico.

OPUNTIA MEGACANTHA Salm-Dyck

Opuntia megacantha SALM-DYCK, Hort. Dyck. 363. 1834.

Type locality: In Mexico.
Distribution: Cultivated in Mexico and Jamaica.

Series STENOPETALAE.

Large white-spined plants with narrow petals.

OPUNTIA GLAUCESCENS Salm-Dyck

Opuntia glaucescens SALM-DYCK, Hort. Dyck. 362. 1834.

Type locality: In Mexico.
Distribution: Mexico.

OPUNTIA GRANDIS Pfeiff.

Opuntia grandis PFEIFF. Enum. Cact. 155. 1837.

Type locality: In Mexico.

Distribution: Mexico.

Illustration: Monatsschr. Kakteenk. 14: 172.

Referred by Schumann to *O. glaucescens*, but doubtless distinct, as indicated by Berger.[1]

OPUNTIA STENOPETALA Engelm.

Opuntia stenopetala ENGELM. Proc. Am. Acad. 3: 289. 1856.

Type locality: On battlefield of Buena Vista, south of Saltillo, Mexico.

Distribution: Coahuila to Queretaro and Hidalgo.

Illustrations: Cact. Mex. Bound. *pl. 66;* Monatsschr. Kakteenk. 14: 172.

Referred by Schumann to *O. glaucescens*, but surely a distinct species, as also indicated by Berger.[1]

LIST OF THE SPECIES OF NOPALEA

NOPALEA COCHENILLIFERA (L.) Salm-Dyck

Cactus cochenillifer L. Sp. Pl. 468. 1753.
Opuntia cochinelifera MILL. Dict. ed. 8. no. 6. 1768.
Nopalea cochenillifera SALM-DYCK, Cact. Hort. Dyck. 63. 1850.

Type locality: Jamaica.

Distribution: West Indies and tropical America.

Illustrations: Bot. Rep. *pl. 533;* Descourt. Fl. Pict. Antilles 7: *pl. 515;* Bot. Mag. 54: *pls. 2741, 2742;* Dill. Hort. Elth. *fig. 383;* Pfeiff. & Otto, Abbild. Cact. 1: *pl. 24;* Kerner, Hort. *683;* Fl. Bras. 4^2: *pl. 60.*

NOPALEA KARWINSKIANA (Salm-Dyck) Schum.

Opuntia karwinskiana SALM-DYCK, Cact. Hort. Dyck. 68. 1850.
Nopalea karwinskiana SCHUM. Gesamtb. Kakteen 752. 1899.

Type locality: In Mexico.

Distribution: Mexico; rare in cultivation.

NOPALEA AUBERI (Pfeiff.) Salm-Dyck

Nopalea auberi SALM-DYCK, Cact. Hort. Dyck. 233. 1850.
Opuntia auberi PFEIFF. Allg. Gartenz. 8: 282. 1840.

Type locality: Cuba.

Distribution: Cuba.

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[1] Monatsschr. Kakteenk. 14: 171.

NOPALEA DEJECTA Salm-Dyck

Opuntia dejecta SALM-DYCK, Hort. Dyck. 361. 1834.
Nopalea dejecta SALM-DYCK, Cact. Hort. Dyck. 233. 1850.

Type locality: Havana, Cuba.
Distribution: Cuba, and common in cultivation in Mexico.

NOPALEA GUATEMALENSIS Rose

Nopalea guatemalensis ROSE, Smithson. Misc. Coll. **50**: 330. 1907.

Type locality: El Rancho, Guatemala.
Distribution: Arid valleys of Guatemala.
Illustrations: Smithson. Misc. Coll. **50**: *pls. 41–42.*

NOPALEA MONILIFORMIS (L.) Schum.

Cactus moniliformis L. Sp. Pl. 468. 1753.
Cereus moniliformis DC. Prod. **3**: 470. 1828.
Opuntia moniliformis STEUD. Nom. **2**: 221. 1841.
Nopalea moniliformis SCHUM. Gesamtb. Kakteen 750. 1900.

Type locality: Tropical America.
Distribution: Haiti.
Illustration: Descourt. Fl. Pict. Antilles **7**: *pl. 514.*
This very interesting species is known to us only from the descriptions and illustration.

OBSERVATIONS ON THE MOSQUITOES OF SASKATCHEWAN

By FREDERICK KNAB

The observations here recorded are the result of an expedition to western Canada during the spring of 1907. Up to the present nothing definite has been known of the habits of the mosquitoes of the northern prairies. Their extreme abundance in that region during the summer and the suffering they cause to man and beast have been frequently reported. Their presence in such large numbers seemed the more mysterious, since water, so essential to mosquito-development, is usually absent or very scarce on these prairies during the summer months. However, we now know that the most important part of the mosquito fauna of the northerly portion of the eastern United States consists of species of the genus *Aedes*,[1] and also that these typically northern forms develop in the snow-water of early spring. It was to be inferred that in the prairie region of the northwest, species of *Aedes* of similar habits would be the predominating forms, and so it proved.

There is but one brood annually of these northern mosquitoes of the genus *Aedes*. The adult mosquitoes live a long time (two or three months) and lay their eggs late in the summer. These eggs lie upon the ground until the following spring, and then hatch in the water from the melted snow. With most of the species the larvæ develop very rapidly and often transform to adults within two weeks. In order to study these mosquitoes and obtain their larvæ, it was necessary to be in the field with the opening of spring, for the season of larval development is very brief. When the writer left Washington, early in April, the magnolias were in bloom, and it was thought that spring would soon open in the north. But when southeastern Saskatchewan was reached, on April 10, the ground was still covered with snow and the weather was cold and windy. The season proved to be an exceptionally backward one, and there was no appreciable change until early in May; indeed, some of the large snow-drifts lasted until early in June.

[1] This name is applied as defined in Dyar and Knab: On the Classification of the Mosquitoes. Canad. Entomologist, vol. XXXIX, 1907, pp. 47–50.

The town of Oxbow, about thirty miles north of the United States boundary, was selected as a suitable location for study. It overlooks the valley of the Souris River, and therefore, besides the typical prairie country, also offers the diversified conditions of the river valley. The prairie is rolling, and in the spring there are numerous pools and small ponds. All but the largest ponds dry out in the course of the spring and summer. It was in these prairie pools of snow-water that mosquito larvæ were found in greatest abundance. On the river bottom-land no larvæ were found, although two species not found on the prairie occurred in the ravines opening upon the river.

The first newly hatched mosquito larvæ were found on May 6, although as yet there had been but few mild days. In fact, on this day there was a strong north wind blowing and icicles formed where the water was dashed against reeds and branches. It was surprising, however, how rapidly the water, particularly in the ditches and smaller pools, was warmed by the sun, so that it was very appreciably warmer than the air. It was in these shallow pools that the larvæ developed most rapidly and in greatest numbers. The details of larval development will be given under the separate species.

In the following account the species are treated in the order of their importance. *Culiseta inornata* Williston, which does not appear until later in the season, and which I did not have an opportunity to collect, is included. We owe specimens of this species to the kindness of Dr. James Fletcher, the government entomologist of Canada, and to Mr. T. N. Willing, of Regina. Eight species of *Aedes* were collected. Four of these, *Aedes spenceri* Theo., *A. fletcheri* Coq., *A. curriei* Coq., and *A. campestris* D. & K., are peculiar to the prairie regions. Two others, *A. fitchii* F. & Y. and *A. fuscus* O. S., occur upon the prairie in lesser numbers. The two species, *A. canadensis* Theo., and *A. subcantans* Felt, were found only in some deep ravines opening upon the Souris River, and do not occur upon the prairie at all. They belong to the eastern wooded region, and have found their way up along the wooded shores of the river. It is significant that they were found only in two ravines, the mouths of which lie close to the river's margin.

AEDES SPENCERI Theobald

This is the common mosquito of the prairies of Saskatchewan, and apparently occupies the entire northerly portion of the prairie region of North America. It is very bloodthirsty, and its excessive abundance makes life upon the prairie a torture during the early summer. The first larvæ of this species were found, newly hatched, at Oxbow, on May 6, in ditches along the railroad. The weather continued cold for some time after this and the pools froze over at night. This apparently did not injure the young larvæ. On May 16 a large number of pools were examined, and it was found that all but the larger pools contained larvæ. The pool from which the young larvæ were obtained on May 6 now contained many larvæ. It was deep and large and the water cool; in consequence the larvæ were still in the second stage. In smaller, shallow pools, where the water was warm, the larvæ were much further advanced. A shallow puddle in the field close by the railroad station, the water of which was remarkably warm, contained numerous larvæ, mostly in the third stage. The larvæ for the most part kept among the grass close to the margin, where the water was warmest and they were best protected from the wind. These larvæ, brought into the house, nearly all molted on the following day. A day later (May 18) a number of the larvæ pupated. In the meantime there had been severe frosts during the nights and the pools were repeatedly frozen over and thawed out again by the sun of the following day. But in spite of this the larvæ developed as rapidly out of doors as in the house, the effect of the sun more than offsetting the retarding influence of the cold nights. The first adults were bred out on May 22. Larvæ continued to increase in numbers during the following week, those in the small warm pools being most abundant and developing most rapidly. The small permanent ponds contained no larvæ. By the end of the month the larvæ of this species had practically all disappeared.

Adults of this species first appeared active on May 30 and a few came to bite. They were first noted in numbers on June 5, a warm, sunny day following four days of cold, cloudy weather. They came drifting before the wind, and during calm intervals were very annoying. At 10.45 a. m., on a rise of ground west of the town, the highest rise on that part of the prairie, a swarm of about 50 males gathered above my head. They emitted a high-keyed piping sound, swinging backward and forward and swaying sidewise, all the time facing the wind. With every gust of wind they were scattered toward the ground, only to reassemble when the wind decreased. When I passed the place again, at 12.45 p. m., the males were still in evidence, although much interfered with by the wind. The same day, at 5.30 p. m., another swarm of males was observed in the upper part of a ravine, where the slopes were gentle. They were going through rapid evolutions, darting forward and upward and dropping back again, but without unison. When disturbed by the wind their flight became more rapid, and sudden gusts caused them to fly to the ground. Several pairs were seen flying off in copula, and once the female was observed approaching the swarm from beneath. There was a second swarm of males farther down the ravine, about half way up the slope, and, like the other, at the margin of the shrubbery filling the bottom of the ravine. In this case a swarm of very small Chironomids was mixed with the lower part of the swarm. In crossing an open field in the river valley at 6.30 p. m. a swarm of males formed over my head and, following me, increased to the number of perhaps two hundred. They disappeared when I approached the woods on the edge of a ravine. This experience was repeated in the field beyond, and upon nearing the edge of the woods the swarm again departed and could be seen in the middle of the field. Several days of cold and cloudy weather followed, during which the mosquitoes remained quiescent. After the heavy rain of the previous night, the afternoon of June 9 was warm and sunny and the mosquitoes exceedingly abundant and active. At 6.30 p. m. I walked toward the river with a companion. As soon as we had left the town the female mosquitoes began to rise out of the grass and alight upon us. There was a brisk breeze blowing and the mosquitoes settled on the leeward side of our bodies, and a cloud of them followed us, keeping for the most part about our legs. These clouds increased rapidly and became very aggressive as we passed down into the valley, where we came upon a cloud of males on the open prairie. When we approached them they formed in two swarms over our heads. My companion, being the bulkier man, attracted a much larger swarm. We thus each had two swarms of mosquitoes about us; the one, of females, kept about the lower part of our bodies, while the other one, of males, kept above our heads. Several copulations were noted. Upon entering a ravine the males all left us and only a part of the females followed. Upon emerging on the other side of the ravine a new swarm of females quickly gathered, and shortly we came upon another large swarm of males, which again concentrated above our heads in separate swarms. It was now 7 o'clock, but still bright daylight at this season of the year. The swarms of males I judged to contain many hundreds, if not a thousand, individuals. These swarms, in close formation, followed us up the long hill and continued with us nearly to the town, in the end being much disturbed by the wind. About 7 o'clock quite a number of copulations were observed. The females approached the swarm from beneath and left it united with a male, the pair drifting away toward the ground and the union lasting but a short time. They copulate face to face, grasping each other with their long legs, the female in the upper position, the male back downward. This day proved the maximum of activity for this species of mosquito. No more swarming of males or matings were observed. On June 10 there was a very high wind, which kept the mosquitoes close to cover. Only a few came to bite, but these were very bloodthirsty. They would rise out of the grass to leeward and fly against the wind, alighting with a perceptible momentum.

June 11 was a hot day, with only light wind. The female mosquitoes appeared less numerous than two days previously. The males were abundant on willow blooms, busily probing for honey.[1] None were seen swarming.

June 12 was warm but windy, yet the males were still found upon the willow catkins, although they could maintain their hold only with difficulty. High winds continued for five days and nothing was seen of the mosquitoes. On June 18 the males had nearly all disappeared; there were none on the willow catkins and only a very few could be found by beating grass and bushes. The females were still in evidence.

This species is strictly diurnal and is only active in full daylight. It hides in the grass of the prairie until disturbed or attracted by some passing animal. It appears that the habit of this prairie mosquito, of flying toward prominent objects, under normal conditions brings it to its source of food, some large warm-blooded animal. The blood-sucking habit is doubtless normal in this species, and other foods, such as the honey of flowers, are to be looked upon as supplementary when blood is not available. The idea that but few mosquitoes can obtain a meal of blood is entirely erroneous—at least with reference to this species. In former times the prairie teemed with warm-blooded animals, of which the great herds of bison, the antelopes, and deer need only be mentioned. At the present day man, horses, and cattle furnish an abundant supply of blood. On the other hand, in the male this same habit of gathering around prominent objects leads them to the same places to which the females are attracted for food, and thus the union of the sexes is brought about.

AEDES FLETCHERI Coquillett

Larvæ of this species in the second stage were found on May 19. They frequented the larger ditches and pools and appeared to be

[1] Knab, Frederick: Mosquitoes as flower visitors. Journ. N. Y. Entom. Soc., vol. XV, 1907, pp. 215.

absent from most of the small pools, which dry out in a few weeks and form the favorite habitat of the larvæ of *A. spenceri.* Although next in importance to *A. spenceri,* this species is very much less numerous. The larvæ develop more slowly, and most of them do not reach maturity until after the larvæ of *A. spenceri* have disappeared. They seemed to thrive best in the deeper reedy pools of a more or less permanent character, where they feed near the bottom, ascending for air from time to time. On May 25 the larvæ were still in the second and third stages, and it was not until May 28 that a larva in the last stage was obtained. June 10 the first pupa was found, and the larvæ were at that time nearly all in the last stage. June 13 pupæ were numerous, and by June 18 the larvæ had all disappeared and only a very few pupæ remained. On May 27 the larvæ, in the third stage, were found in ditches and in a permanent swamp which were so strongly alkaline that there was a white deposit along the margins. In the alkaline ditches pupæ and full-grown larvæ of *A. spenceri* and small larvæ of *A. curriei* were associated with the larvæ of *A. fletcheri.* The adults bite in the daytime and also toward evening.

AEDES FITCHII Felt and Young

The larvæ of this species were usually found associated with those of *A. fletcheri,* although usually in still smaller numbers. They develop at the same time with *fletcheri* and their growth is equally slow.

On the evening of June 19 I was fortunate enough to observe the swarming of this species in a shallow depression at the head of one of the ravines near Oxbow. The ground sloped gently from the prairie, which at that point was 15 or 20 feet above the bottom of the depression. When the swarm of males was first noticed, at 8.30 p. m., it was loosely organized, and there were perhaps forty individuals, which gyrated and circled about close to the ground. Close by there were some thorn bushes, and between and around these there were several swarms of Chironomidæ, but no mosquitoes. In a short time other swarms of mosquitoes began to form in the open, along the bottom of the depression and on the western slope, where they were protected from the wind. These various swarms kept close to the ground and spread out in such a way that they might be said to have been loosely connected, but still there were foci where the mosquitoes were massed closer together. At no time was the top of a swarm more than four feet above the ground, while it spread out to at least twice that diameter. The size of the swarms gradually increased until, at 9 o'clock, one swarm contained several hundred males. Copulation took place most frequently between 9 and 9.15, but matings were observed both earlier and later. The females entered the swarm from beneath, when they were seized by one or more males. Union takes place "face to face," the pair flying obliquely upward for several yards. Then the pair would either separate promptly or swing out end to end and struggle to disengage themselves. In this latter case both of them could be seen to jerk violently and rapidly in their efforts to free themselves, and the pair would slowly rise, but make no appreciable progress in either direction. When two males seized a female the group would rise straight into the air, apparently engaged in a violent struggle, one of the males finally uniting with the female or all of them separating. In one case four individuals rose thus, scrambling over each other, so to speak. The swarm was watched until 9.30, when the twilight was already quite deep; copulation appeared to have ceased and the swarms were gradually breaking up.

AEDES CURRIEI Coquillett

This species is far less generally distributed over the prairie than the preceding three species, and appears to be a straggler from the prairie regions farther south. The larvæ appear somewhat later than those of *A. spenceri,* and in consequence the adults appear a little later. The larvæ were found in large numbers in a small swamp in the Souris River valley about three miles west of Oxbow. They were also found in small numbers in several permanent ditches along the railroad. At Carnduff they were found in a ditch of alkaline water. In the swamp first mentioned there were full-grown larvæ and pupæ on May 30, but young larvæ in the first and second stages were by far the most numerous.

AEDES CAMPESTRIS Dyar and Knab

Eight specimens of this species were taken on June 18 and 19. The females came to bite in the daytime; the males were obtained by beating bushes at the head of a ravine. It appears to be rare, and no larvæ were obtained. Mr. T. N. Willing found this species at Regina, Carnduff, and Qu'apelle.

AEDES FUSCUS Osten Sacken

A few larvæ of this species were obtained on two occasions, once in a permanent ditch and again in the shallow water at the mouth of a culvert, the remains of a stream of snow-water. The first adults issued from the pupæ on June 17.

AEDES CANADENSIS Theobald

Young larvæ of this species were first found on May 17 in a water-hole at the bottom of a deep, narrow ravine near Oxbow. At that time another deep well-hole, farther down the ravine and well protected by bushes, contained no larvæ. On June 7 both of these water-holes contained numerous larvæ; in the more sheltered one they were present in immense numbers. At this time there were many larvæ of *Aedes subcantans* associated with the *canadensis* larvæ; on June 14 the *subcantans* had nearly all disappeared, but *canadensis* in second, third, and fourth stage and in pupa were present in thousands. In another ravine a large vat, which on June 4 still contained ice, on June 14 contained larvæ of *canadensis* in the second and third stages. On June 12 numbers of larvæ of this species in the third and fourth stages and a few pupæ were found in water-filled cattle-tracks at the lower ends of these same ravines. The first adults of *A. canadensis* issued from the pupa on June 13.

AEDES SUBCANTANS Felt

The larvæ of this species were found associated with those of *A. canadensis* in a deep ravine. The larvæ developed somewhat earlier than the majority of the *canadensis* larvæ, and they were far less numerous.

CULISETA INORNATA Williston

This species breeds throughout the summer, the females hibernating and depositing their eggs the following season. It has been taken by Mr. T. N. Willing at Regina, Carnduff, Shepard, Kimistino, Olds, and Maple Creek.

NOTES

Hodgkins Fund Prize for Treatise on Tuberculosis

The Smithsonian Institution has made the following announcement in regard to the award of a prize of $1,500 for the best treatise "On the Relation of Atmospheric Air to Tuberculosis," to be submitted to the International Congress on Tuberculosis, which will be held in Washington September 21 to October 12, 1908:

Smithsonian Institution

Hodgkins Fund Prize

In October, 1891, Thomas George Hodgkins, Esquire, of Setauket, New York, made a donation to the Smithsonian Institution, the income from a part of which was to 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." In furtherance of the donor's wishes, the Smithsonian Institution has from time to time offered prizes, awarded medals, made grants for investigations, and issued publications.

In connection with the approaching International Congress on Tuberculosis, which will be held in Washington September 21 to October 12, 1908, a prize of $1,500 is offered for the best treatise "On the Relation of Atmospheric Air to Tuberculosis." Memoirs having relation to the cause, spread, prevention, or cure of tuberculosis are included within the general terms of the subject.

Any memoir read before the International Congress on Tuberculosis, or sent to the Smithsonian Institution or to the Secretary General of the Congress before its close, namely, October 12, 1908, will be considered in the competition.

The memoirs may be written in English, French, German, Spanish, or Italian. They should be submitted either in manuscript or typewritten copy, or, if in type, printed as manuscript. If written in German, they should be in Latin script. They will be examined and the prize awarded by a committee appointed by the Secretary of the Smithsonian Institution in conjunction with the officers of the International Congress on Tuberculosis.

Such memoirs must not have been published prior to the Congress. The Smithsonian Institution reserves the right to publish the treatise to which the prize is awarded.

No condition as to the length of the treatises is established, it being expected that the practical results of important investigations will be set forth as convincingly and tersely as the subject will permit.

The right is reserved to award no prize if in the judgment of the committee no contribution is offered of sufficient merit to warrant such action.

Memoirs designed for consideration should be addressed to either "The

Smithsonian Institution, Washington, District of Columbia, U. S. A.," or to "Dr. John S. Fulton, Secretary General of the International Congress on Tuberculosis, 714 Colorado building, Washington, District of Columbia, U. S. A." Further information, if desired by persons intending to become competitors, will be furnished on application.

CHARLES D. WALCOTT,
Secretary of the Smithsonian Institution.

WASHINGTON, D. C., *February* 3, 1908.

REPORT BY PROF. W. G. FARLOW, REPRESENTATIVE OF THE SMITHSONIAN INSTITUTION AT THE BICENTENNIAL OF THE BIRTH OF LINNÆUS, HELD AT UPSALA AND STOCKHOLM MAY 23-25, 1907

* * * Although the invitations to attend the Linnéfest were issued, one by the University of Upsala, the other by the Royal Swedish Academy of Sciences, the celebration was not confined to those two learned bodies, but the whole Swedish nation, from the royal family to the school children, united to honor the memory of their greatest naturalist. The shops were gay with flags and portraits, processions of children paraded the streets, and everywhere one saw sprigs of artificial but lifelike *Linnæa borealis* worn as personal adornments or used as table decorations.

The formal celebration began on May 21 with a visit to Råshult, the birthplace of Linnæus, near Lund, under the guidance of officers and students of the University of Lund. In front of the house, which replaces the one in which Linnæus was born, a commemorative obelisk was erected in 1866. Owing to an accident on the journey from Hamburg, I was unable to attend the exercises at Råshult and was obliged to proceed directly to Stockholm, whence, on the morning of May 23, a special train conveyed the delegates and invited guests to Upsala. We were met at the station by the students in a body, bearing the gay banners of the different student-nations, or provinces, each of the thirteen provinces of Sweden having its own club-house, some of them fine, substantial buildings. After a song and a speech, for in their fondness for speech-making the Swedes are not inferior to our own countrymen, the delegates were escorted to their quarters, and there was a general scramble to prepare for the opening exercises in the Aula at noon. The delegates, 51 in number from 15 foreign countries, together with officials and invited guests, were escorted to the Aula, and, after the arrival of the royal family, the national anthem was sung, followed by an address from the Rector of the University and the singing of a cantata by a chorus and soloists.

The delegates, arranged alphabetically by nations, then marched across the platform and presented their congratulatory addresses, one person from each nation being appointed to act as spokesman, the speeches not to exceed three minutes. The alphabetical arrangement, which placed America at the head of the list, was somewhat embarrassing to us, since we were less familiar than others with the customs of Sweden and we had to trust to nature rather than established custom in making our salutations. After the conclusion of the exercises in the Aula the delegates were presented to the Prince Regent in an antechamber. A student concert in the afternoon and a dinner by the Rector of the University in the hall of the Norrland Nation closed the first day of the celebration.

The exercises on the following day were ushered in by a salute of cannon at 7:00 a. m., and the town was crowded with people who had come from a distance to see the bestowal of degrees in the Cathedral. It was on this day that the traditions and customs of the Swedish universities—unchanged for centuries—were most impressive. At noon the procession of the "promovendi," or those about to receive honorary degrees, entered the Cathedral, in which is the tomb of Linnæus, in the presence of a large crowd, consisting largely of ladies. After the singing of a cantata composed by Josephson for a University celebration in 1877, and a Festrede, the degrees were conferred in the departments of theology, law, medicine, and philosophy, the candidates being arranged in corresponding groups.

Those in the different faculties were conferred by the Dean of the faculty, who, as a candidate reached the platform, placed on his finger a gold ring and on his head, if he were a doctor of philosophy, a laurel wreath, or, if a doctor of theology, law, or medicine, a silk hat of the size of the ordinary silk hat, but with vertical folds which no words can describe.

As the wreath or hat was placed on the head of each doctor a cannon was fired (in the case of the Jubeldoktar, Prof. Ernst Haeckel, of Jena, two shots were given) and he then passed the Chancellor of the University and the royal family, saluting them, and returned to his original place.

After leaving the Cathedral the newly made doctors received the congratulations of the students on the steps of the Aula, and Prince Eugen, the only literary member and the most beloved of the royal family, replied in behalf of the doctors. In the evening the grand banquet, attended by the delegates, high officials, and the royal family, including two ladies, was given in the Aula.

On May 25 a special train took the guests back to Stockholm, where the celebration of the Royal Academy of Sciences took place at the Academy of Music at 2 p. m. The exercises here were similar to those on the opening day at Upsala. A really beautiful original cantata was sung, and, after a speech by the President of the Academy, Count Mörner, the Linnæan gold medal was bestowed on Sir Joseph Dalton Hooker. As owing to his great age, 89 years, he could not be present, the medal was handed to the British Ambassador, to be transmitted to him. The delegates, native and foreign, then presented their congratulations as at Upsala, this time, however, America being at the end instead of at the head of the procession. In the evening a grand dinner was given at the famous Hasselbacken restaurant, known to all travelers, and the formal festivites ended with a garden party by the Prince Regent on Sunday, the 26th.

It is only necessary to add that all arrangements for the Linnéfest had been most carefully planned and were carried out without a mishap. Our hosts were unsparing in their efforts to make our visit pleasant. The labor of preparing for so elaborate a festival must have been very great, for not only were the details of the meetings complicated, but in honor of Linnæus different learned bodies prepared a considerable number of volumes relating to Linnæus and his work and influence, which must have been very costly both in preparing and printing.

No naturalist was ever so completely honored by his countrymen as was Linnæus.

PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

CONTINUED FROM LIST IN QUARTERLY ISSUE, VOL. IV, PART 3

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1786	BRITTON, N. L., and ROSE, J. N. A Preliminary Treatment of the Opuntioideæ of North America. (*Quarterly Issue*) 1908	M.C. L	.10
1787	KNAB, FREDERICK. Observations on the Mosquitoes of Saskatchewan. (*Quarterly Issue*) 1908	M.C. L	.05
1788	NOTES to *Quarterly Issue,* Vol. IV, Part 4	M.C. L	.05
1789	Smithsonian Miscellaneous Collections (*Quarterly Issue,* Vol. IV), Vol. L. 1908	M.C. L	
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